The fringe-tracker SPICA-FT

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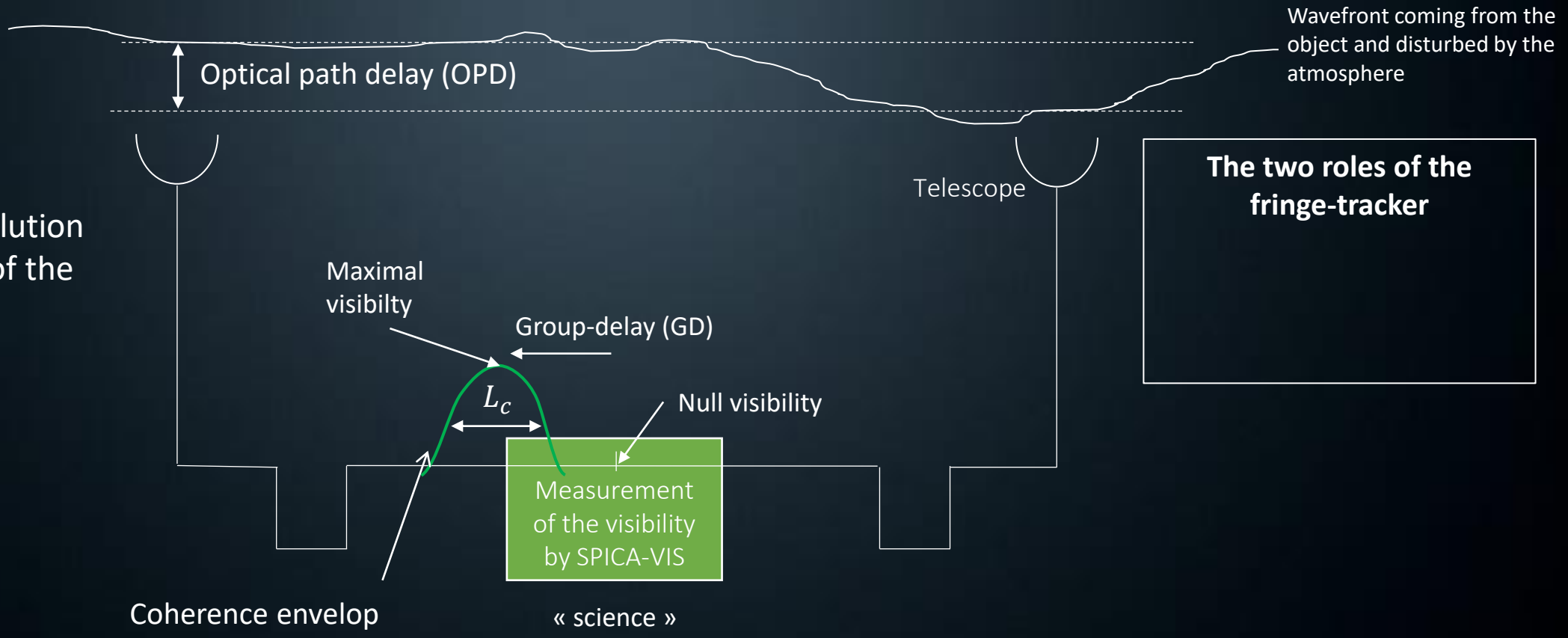
0 Plan

1. Why a fringe-tracker ?
2. Current work on SPICA-FT
3. Fringe-tracking for SPICA-VIS
4. Operating mode of SPICA-FT

0 A fringe-tracker, what for ?

Optical path delay

Coherence length :
$L_c = R\lambda$
où :
- R = spectral resolution
- λ = wavelength of the measurement



The two roles of the fringe-tracker

0 A fringe-tracker, what for ?

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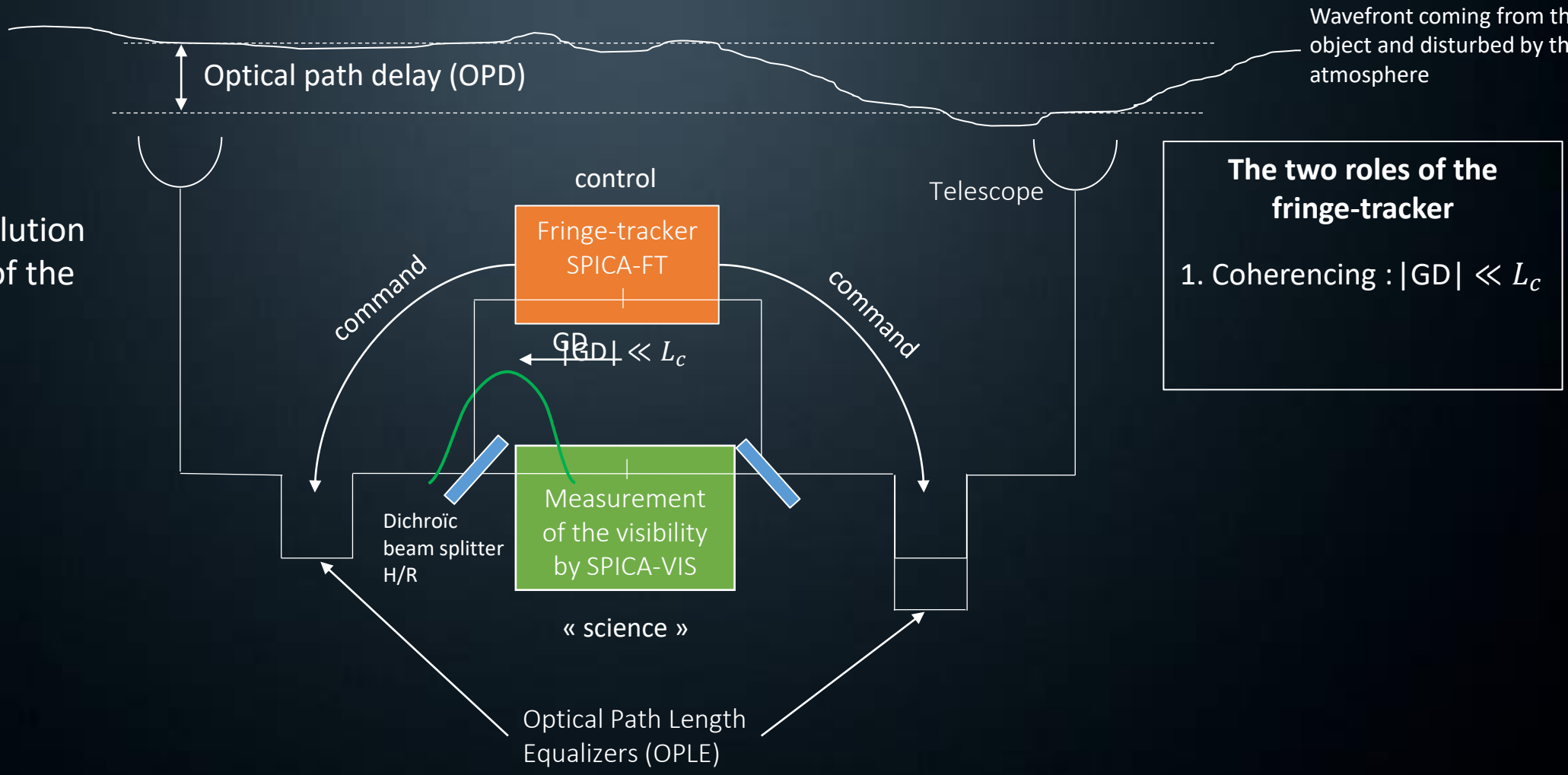

The two roles of the fringe-tracker

1. Coherencing : $|GD| \ll L_c$

A fringe-tracker, what for ?

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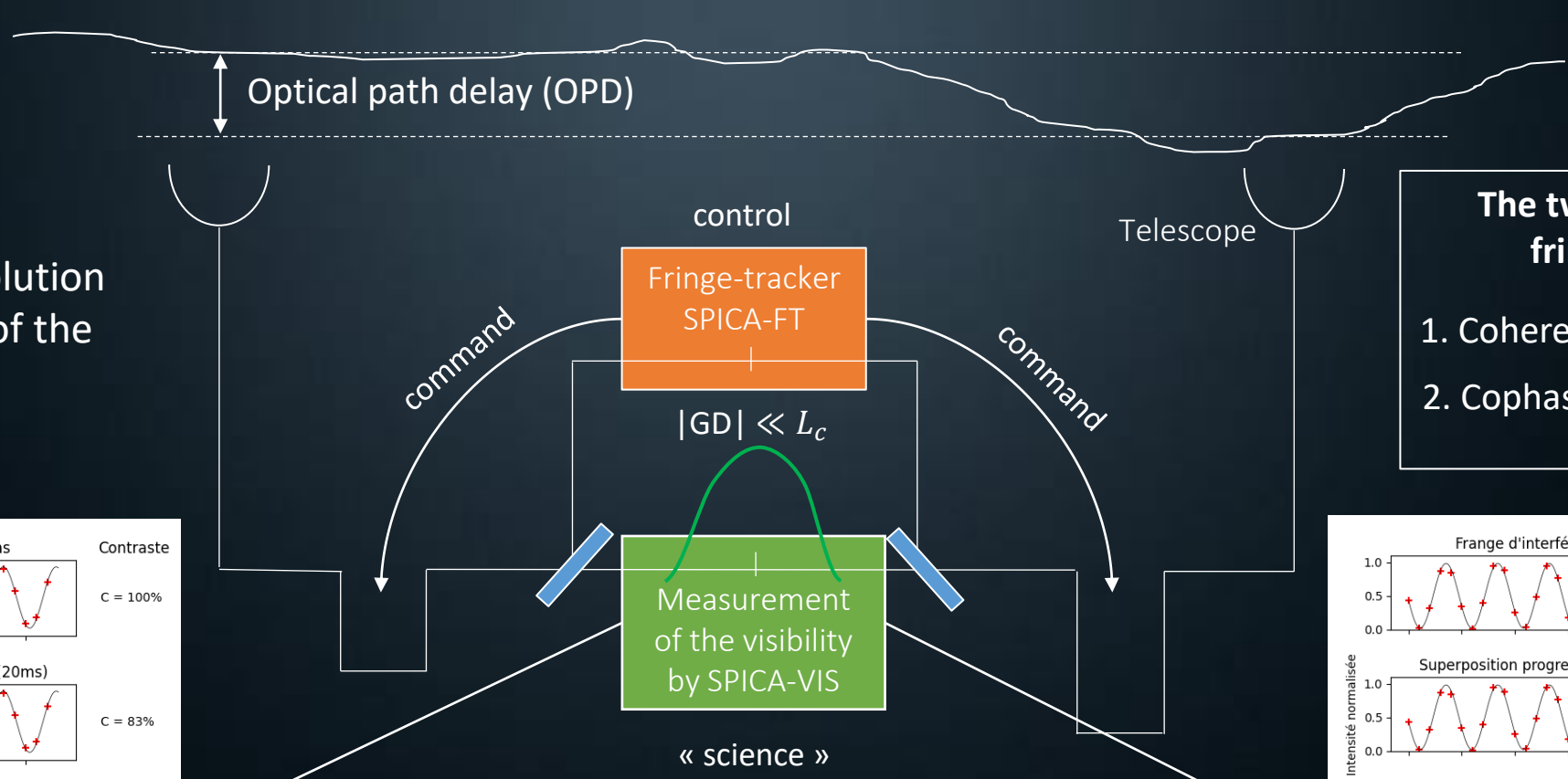
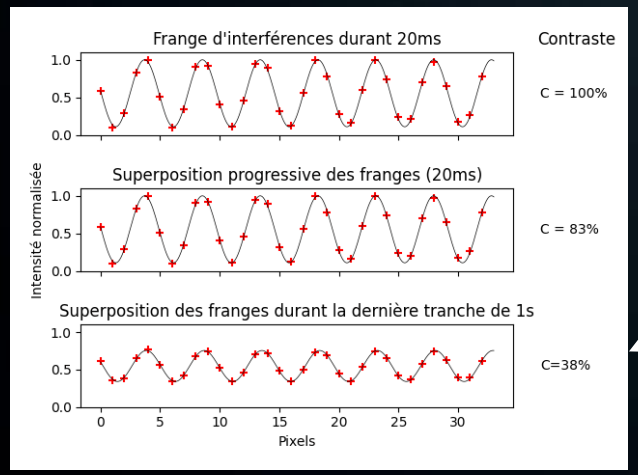
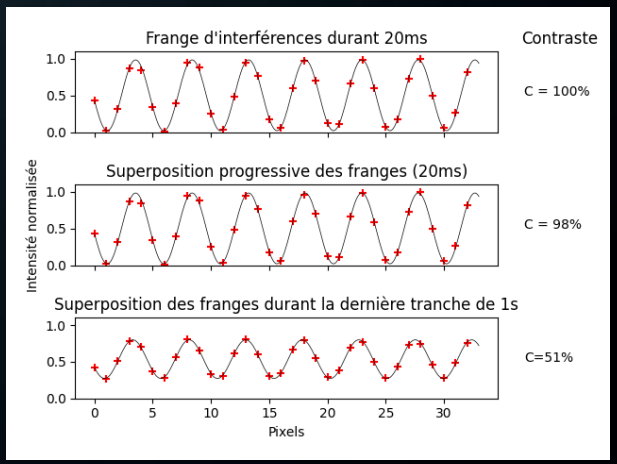


The two roles of the fringe-tracker

1. Coherencing : |GD| ≪ L_c
2. Cophasing : $\sigma_{OPD} \ll \lambda$



Jittering fringes



Cophased fringes

Current work

Current status

- The six telescopes of CHARA are currently kept in coherence by MIRC-X group-tracker
- We achieved phase-tracking with SPICA-FT last year and we are now constantly improving the software
- We are starting gathering MIRC-X telemetries to assess MIRC-X group-tracker performance before doing the same with SPICA-FT
- The integration of the IO/ABCD is in preparation

1 Current work

August 2022

First cophasing of CHARA

Cophasing of the six telescopes on August 15th 2022 on the star HD3360

Conditions

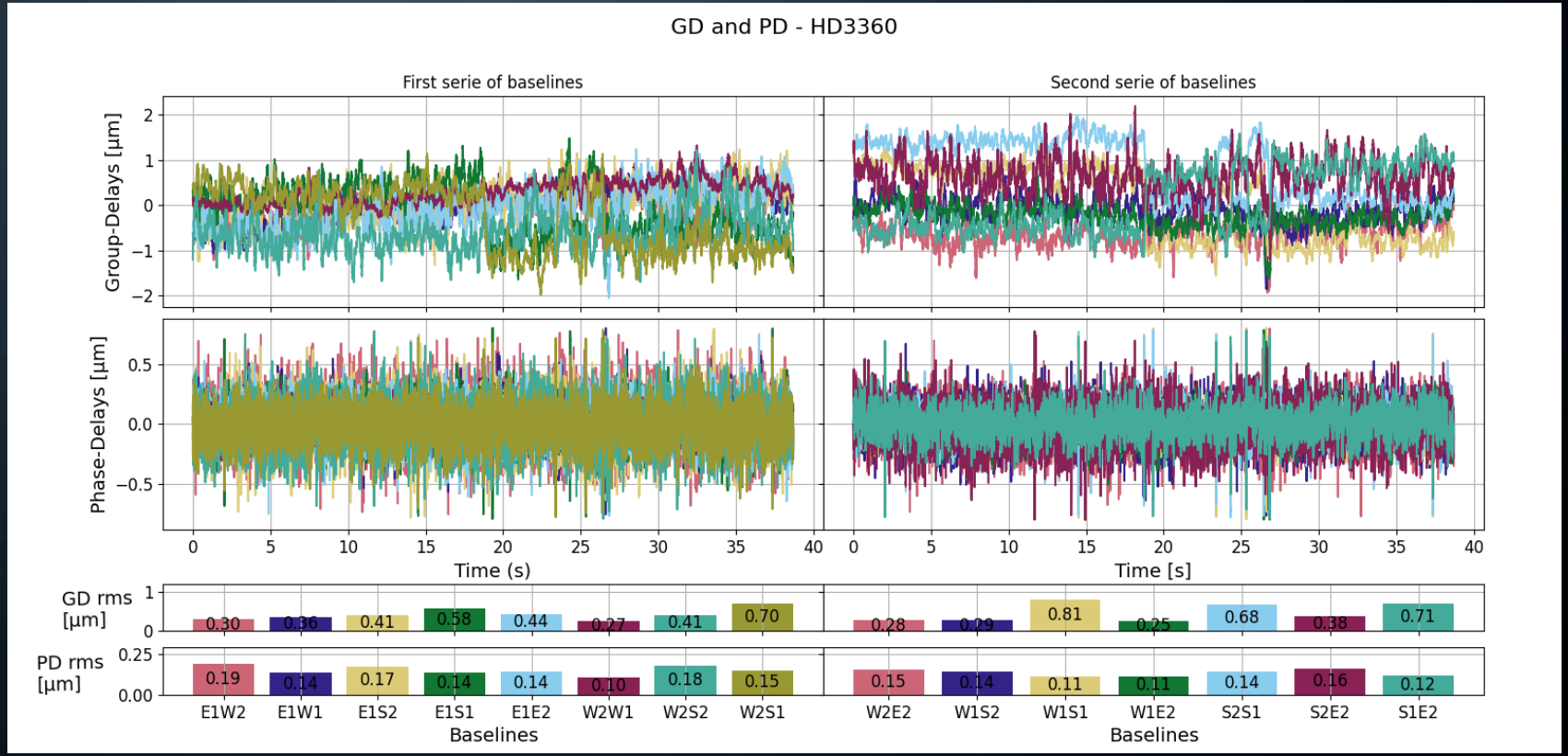
Star HD3360 :

- $m_H = 4{,}2$
- $\theta \simeq 0{,}3$ mas ($|V_H| > 0{,}8$)

Atmosphere : $r_0 \simeq 11$ cm

Performance

- In average : 140 nm RMS
- Best : 100 nm RMS

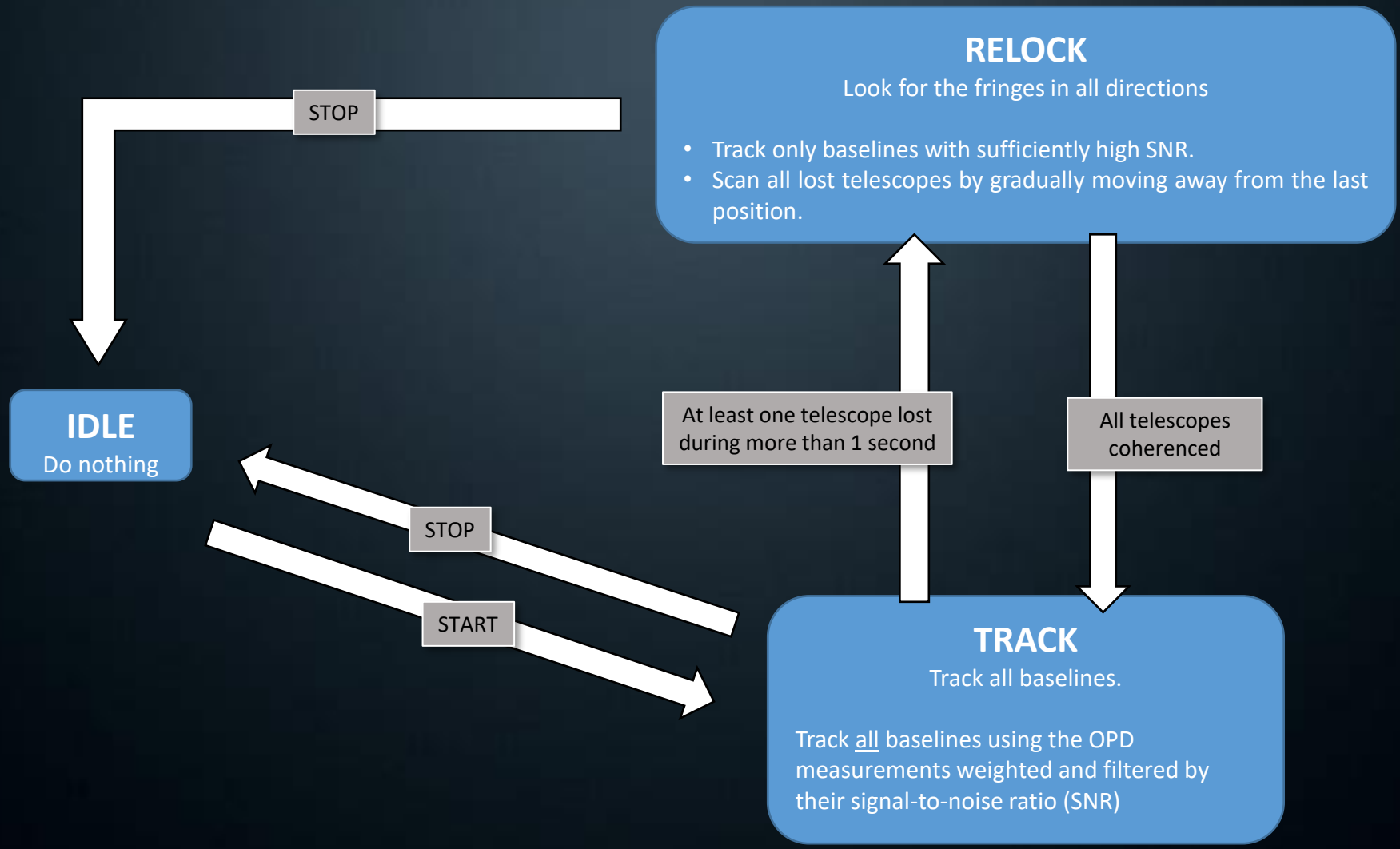


Take-home message

- We proved the ability of reducing perturbations down to 100 nm rms.
- We need to reach this level of cophasing on magnitude 7 to 8 in various atmospheric conditions.

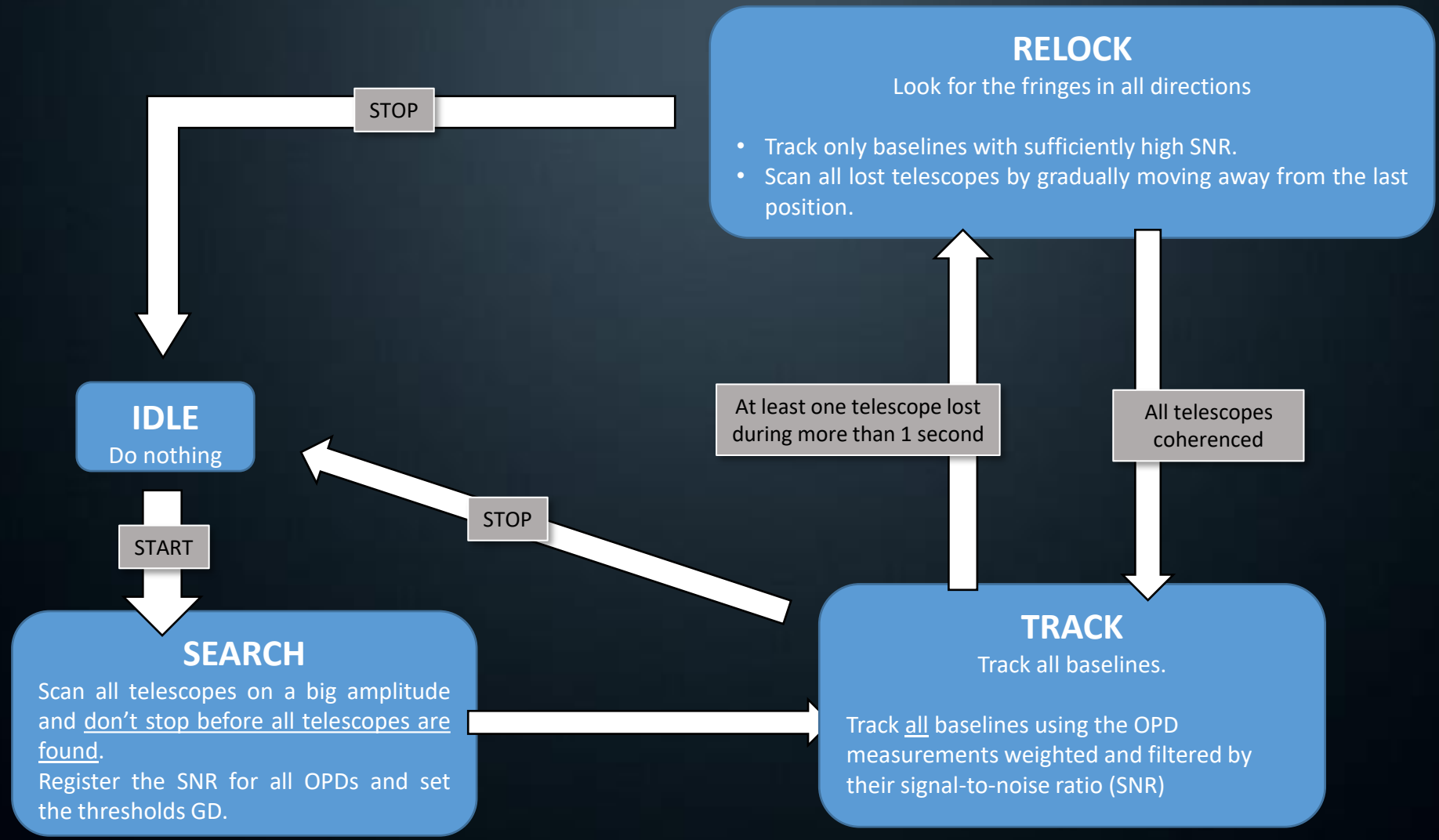
1 Current work

STATE machine



1 Current work

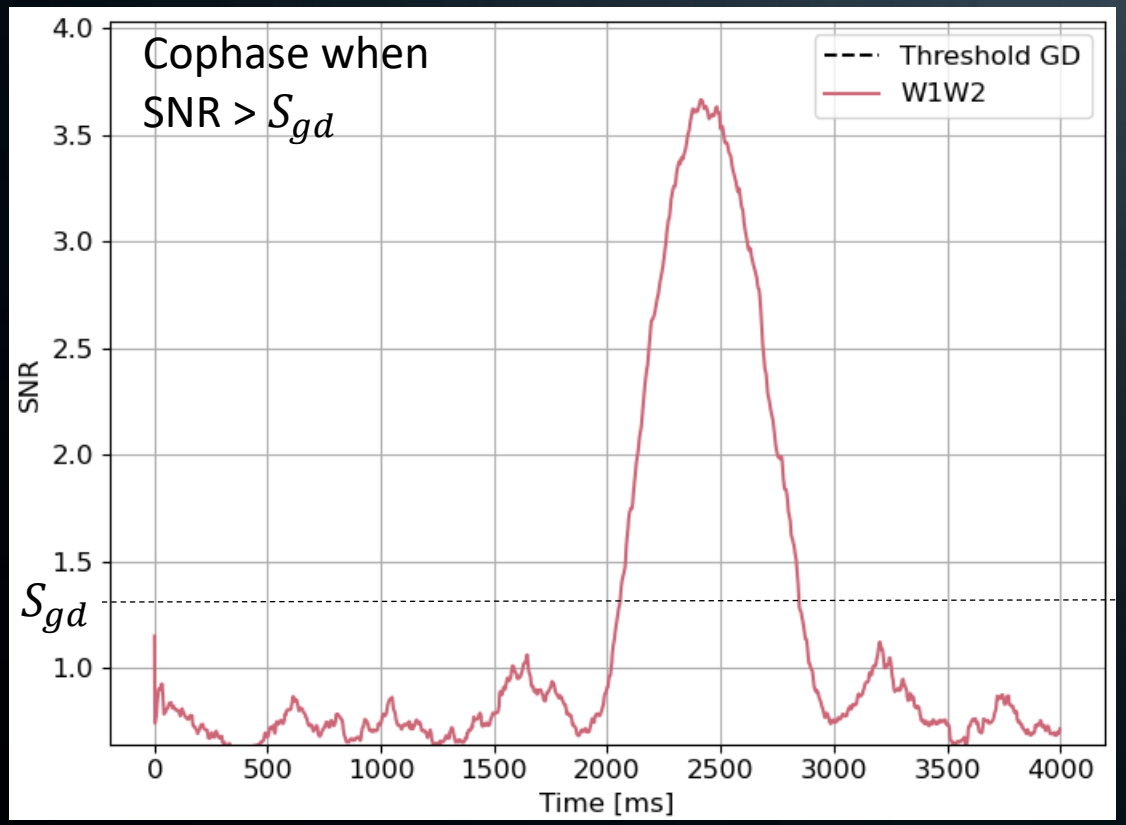
STATE machine



Current work

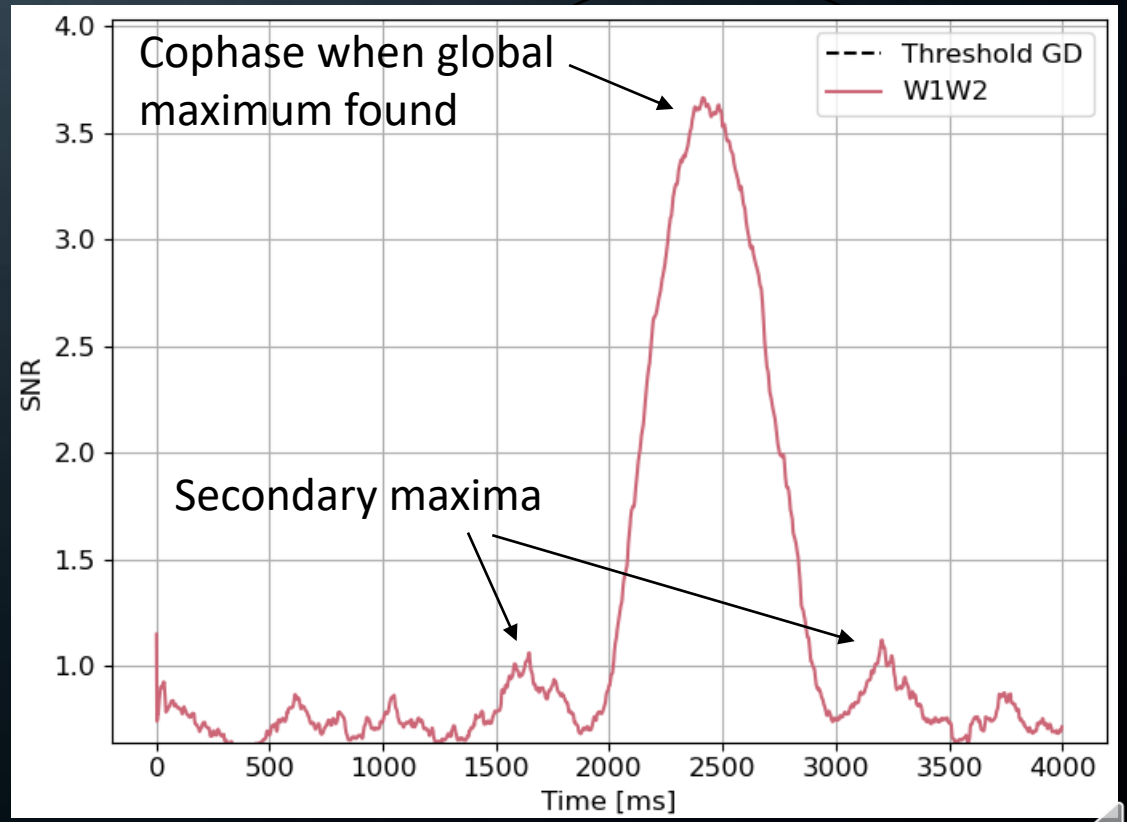
RELOCK

- Immediately cophases baselines when fringes are found
- Fringe detection: SNR > S_{gd}



SEARCH

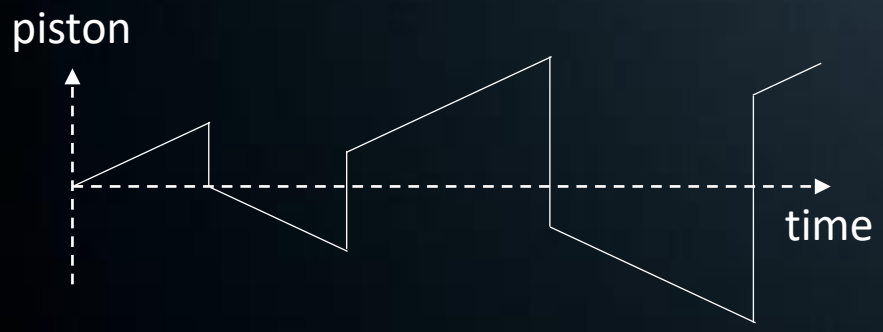
- Finds N-1 independent baselines before cophasing the array
- Fringe detection: global maximum detected

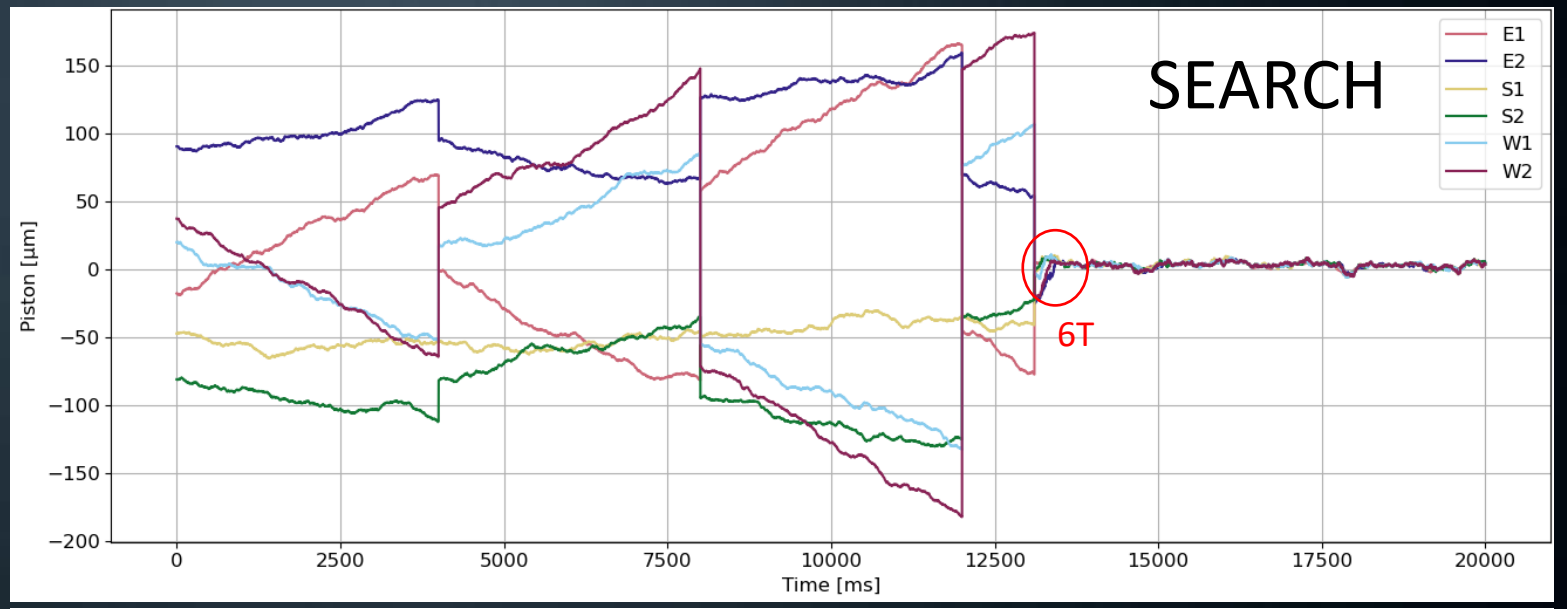


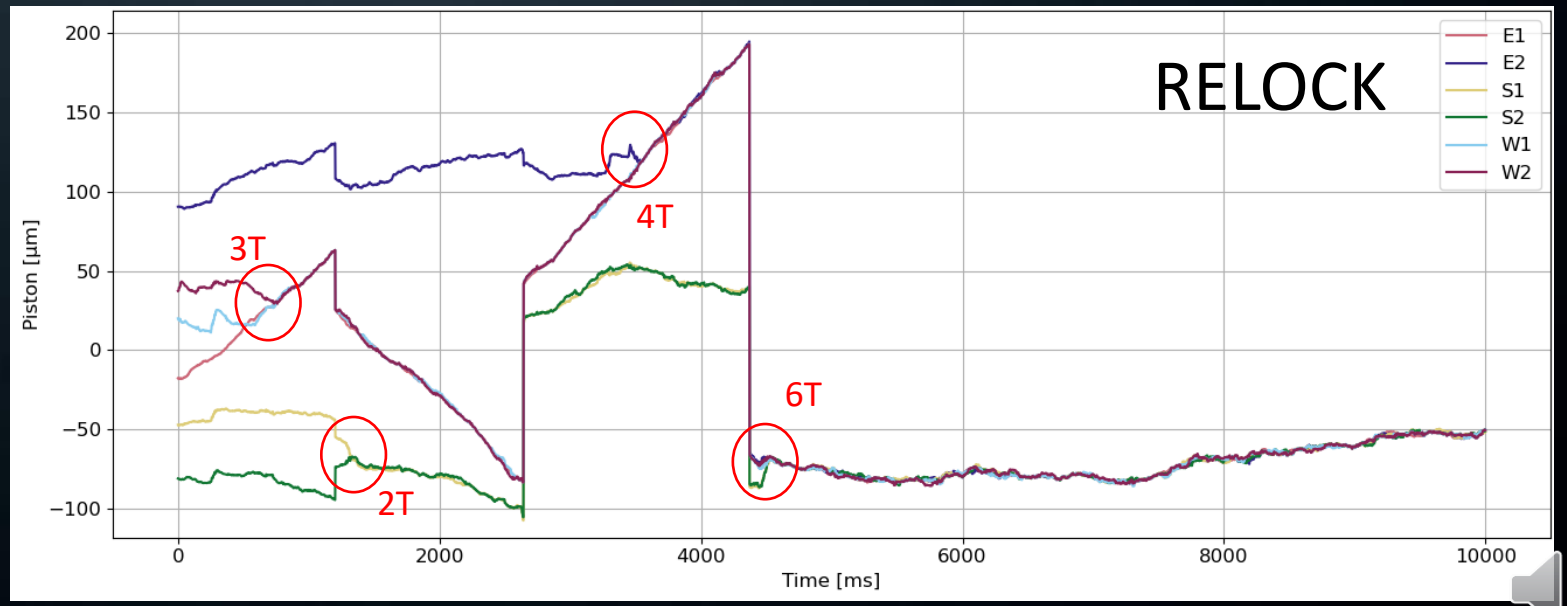
1 Current work

SEARCH / RELOCK ?

Sawtooth function:







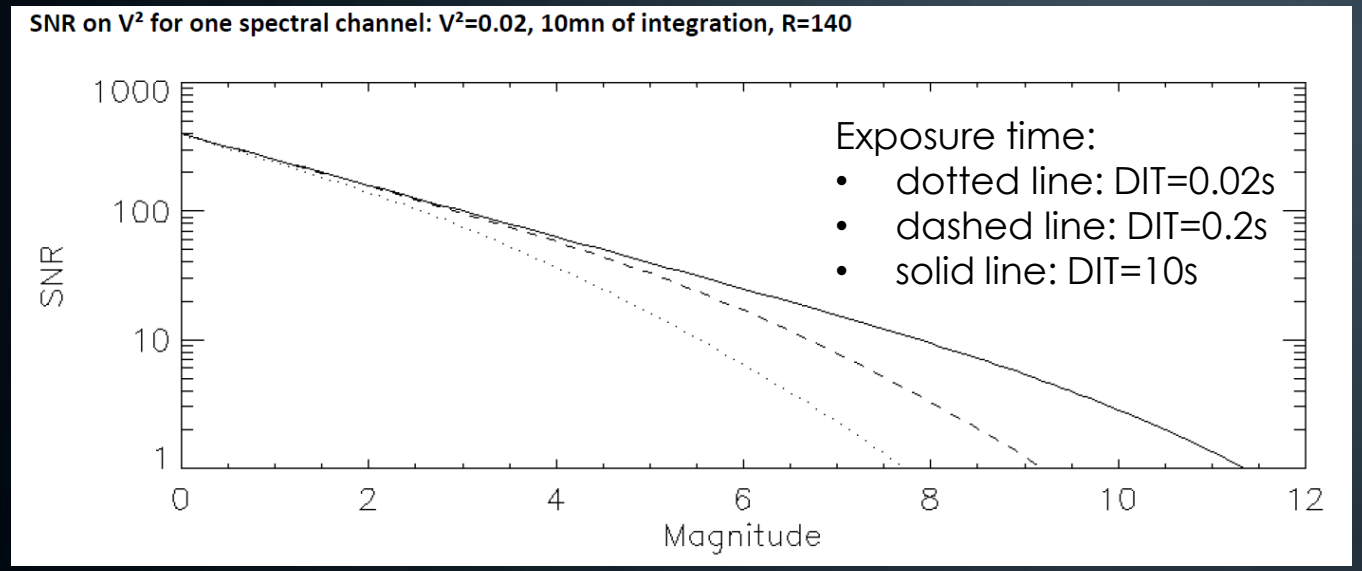
Current work

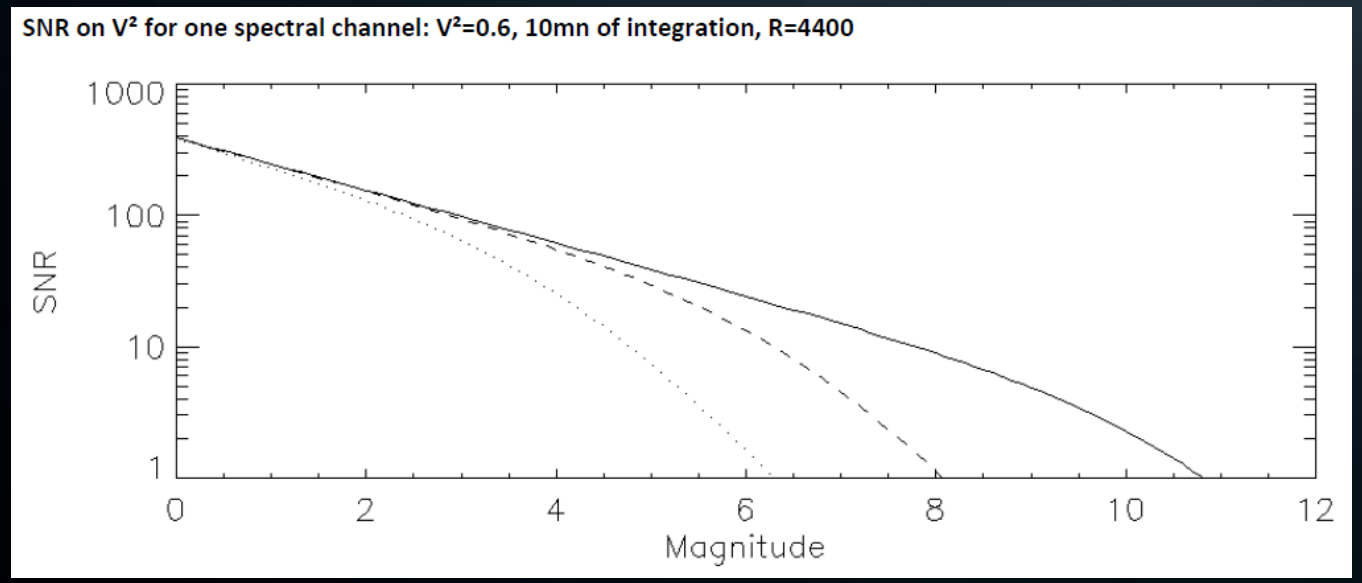
SEARCH / RELOCK ?

- Should we use the SEARCH state when starting SPICA-FT ?

	RELOCK	SEARCH
PROS	• Cophases baseline as soon as it is found • Cophases the array faster	• Doesn't need *a priori* SNR thresholds • Can't cophase on a secondary lobe • Can be used for setting the SNR thresholds
CONS	• Can track on a secondary lobe • Needs a predefined SNR threshold	• Doesn't cophase immediately baselines that have been found • Wait several minutes before cophasing • More complex algorithm

A fringe-tracker for SPICA-VIS





Original idea of SPICA-FT

Supplying cophasing capabilities to the CHARA array for pushing sensitivity in the visible (SPICA-VIS)

Goal

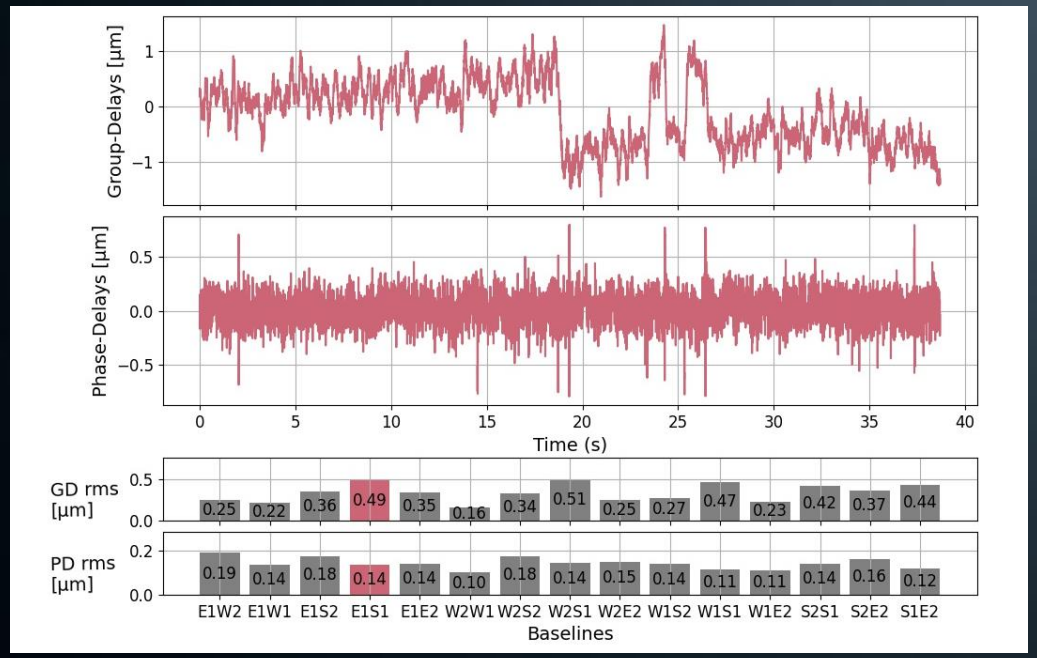
Assuring $\sigma_{\Delta\Phi} < \lambda/6$ in the visible ($\lambda = 750$ nm) over hundreds of milliseconds

→ $V_{loss} \simeq 30\%$

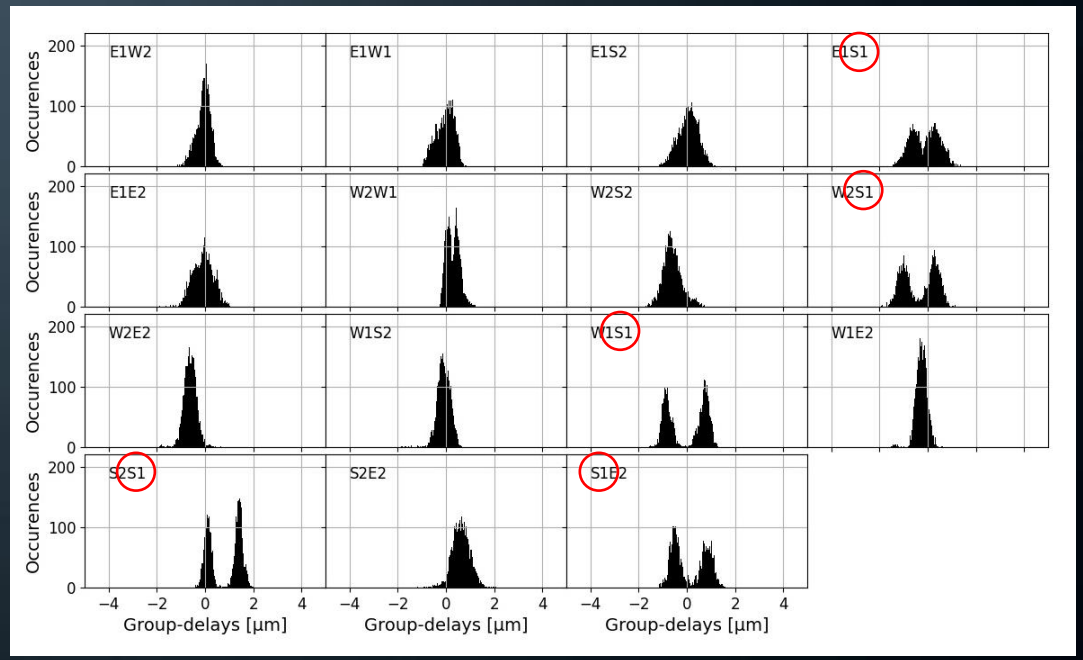
2 A fringe-tracker for SPICA-VIS

Limiting fringe jumps

Fringe jumps on the baseline E1S1 on August, 15th 2022



Histograms of the measured group-delays on the fifteen baselines



Fringes are blurred at $\lambda_{SI} \neq \lambda_{FT}$

How to reduce this behaviour ?

- GD command computation different from GD integration
- Synchronisation of the fringe-tracker with the observing instrument

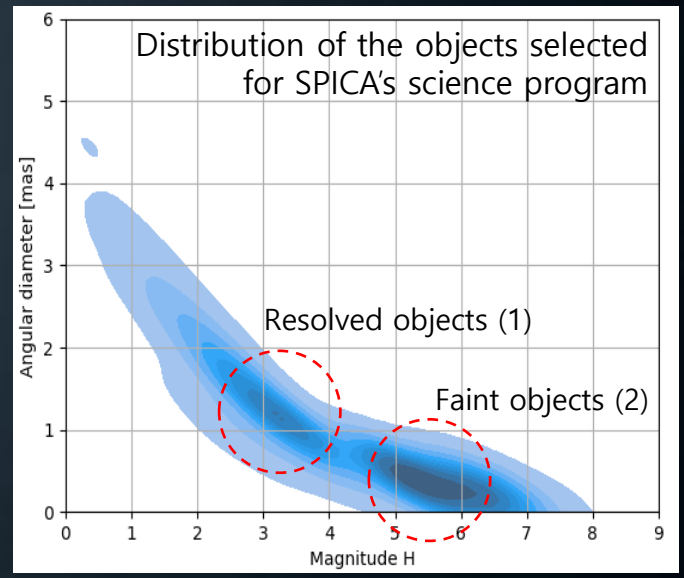
2 A fringe-tracker for SPICA-VIS

The objective is to **quantify the performance** regarding several criteria:

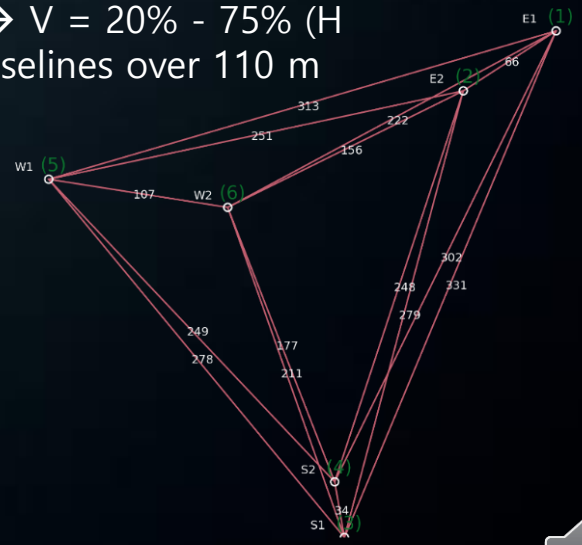
- Behaviour regarding **the heterogeneity of objects and visibilities**:
  - Resolved objects: low magnitude and visibilities
    → Resilience of the bootstrapping
  - Faint objects: high magnitude and visibilities
    → Limiting magnitude for performant cophasing

- Relation between **atmospheric conditions** and fringe-tracking performance (standard deviation, fringe jumps, spectral decorrelation)

- **Maximal integration time** enabled for SPICA-VIS



1 mas star → V = 20% - 75% (H band) for baselines over 110 m



3 SPICA-FT operating mode

A qualified robust and routine cophaser for CHARA

OPD measurements
MIRC-X or MYSTIC

feed

SPICA-Fringe-Tracker
SPICA-FT's state-machine computes the OPD commands and send it to OPLE

improves

Visibility measurements
Any instrument on CHARA
(SPICA-VIS, MIRC-X, MYSTIC, CLASSIC/CLIMB, Silmaril)

SPICA-FT objectives

- Routine cophaser of CHARA ($\sigma_{OPD} < 125$ nm)
- Using MYSTIC or MIRC-X instruments as fringe-trackers
- Enabling simultaneous RJHK visibility measurements with long exposures !

Thank you for your attention