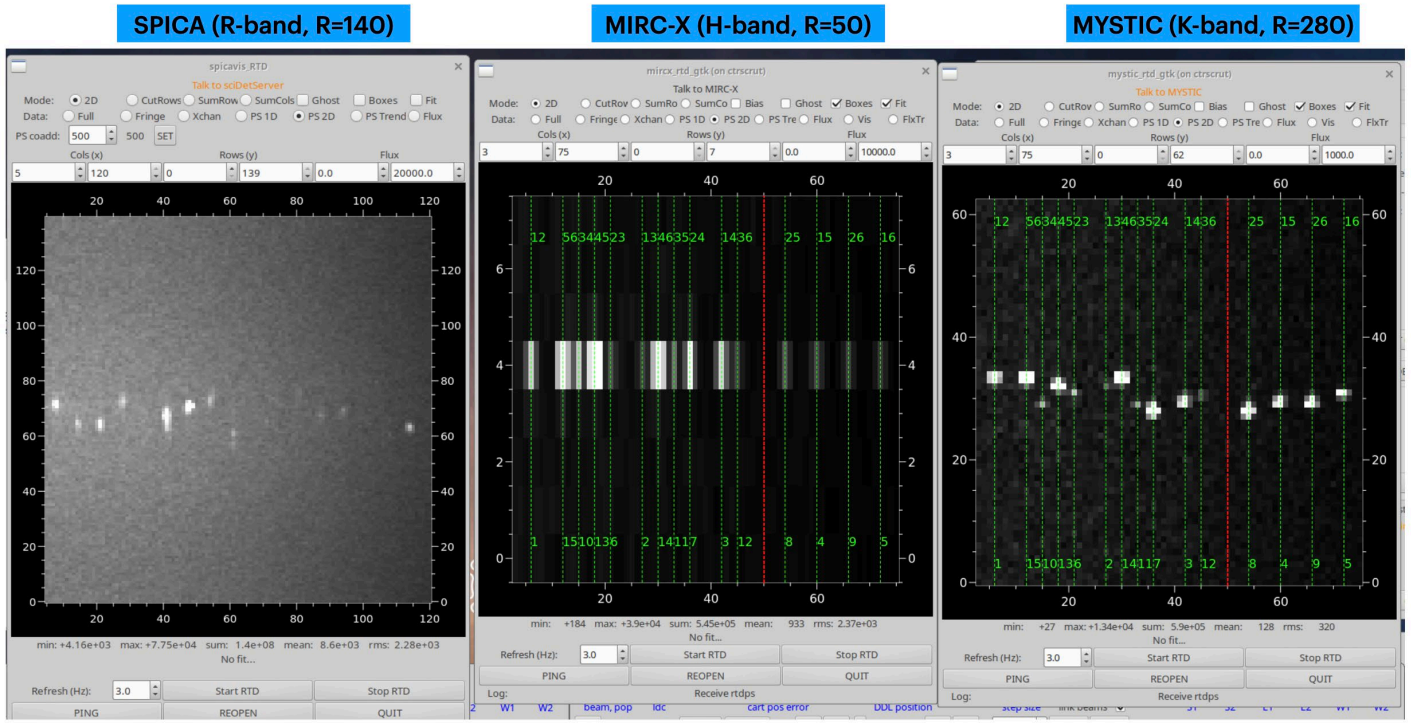
SPICA Progresses in 2024

D. Mourard & SPICA + CHARA + ISSP teams

Routine operations of three combiners

July 2023: 3x15 fringes. Start of science programs



- MIRC-X/MYSTIC
  - 6 telescopes, near-infrared H and K-bands (1.6, 2.3 µm)
  - Spectral resolving power R=50 to 1700
  - Sensitivity: H = 7.5 mag
  - PI: Monnier (Univ. Michigan), Kraus (Exeter)
- SPICA
  - 6 telescopes, visible light (600 – 900 nm)
  - Spectral resolution R=140, 4000, 14000
  - Sensitivity: V = 5.5 mag (shared-risk mode)
  - PI: Mourard (Observatoire Côte d'Azur)

- Longitudinal Dispersion Correction with Common LDC (R-H-K), Visible LDC (R only), and SPICA Differential Delay Lines (R) + MYSTIC DDL (K)

CHARA/SPICA ISSP Project

Denis Mourard

CHARA/SPICA ISSP Project

S01	S02 - S03 ★	S04 ★	S05 ★	S06 ★	S07	S08
Exoplanet host stars	Asteroseismic stars	Surface Brightness Color Relation	Limb darkening	Binaries	Rotation	Winds & environments

Hugo Nowacki

Fabien Patru

Matthieu Vrard

Orlagh Creevey

Sébastien Deheuvels

Romina Ibañez Bustos

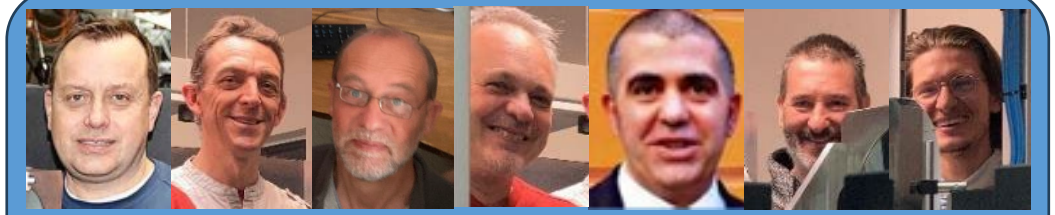
Nicolas Nardetto

Nayeem Ebrahimkutty

Juraj Jonák

Armando Domiciano

Markus Wittowski



Philippe, Julien, Fred, Daniel, David, Christophe, and Pierre

SPICA Data Flow

Interferometric Survey of Stellar Parameters

Data Feeding and Querying Software

A joint OCA / JMMC development

spica_autoCalib.py
spica_merger.py
spica_binnner.py
https://spicaweb.oca.eu

Exploitation

SPICA-Survey | SPICA-Proposals

SPICA-DFQS

DFQ-API

Preparation

JSDC | BadCal

SPICA-Runner

SPICA-NSS

NS-API

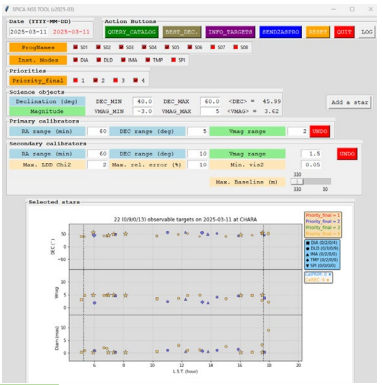
SPICA-DB Targets ISSP | Prim. Cals | *Targets Ext*

SPICA-FUp L1 Spica/Mircx/Mystic ISSP | +L2

L1 Spica Ext. Prog. | +L2

JMMC ObsPortal | OiDB

ISSP-SciCat ISSP-C | ISSP-S01 | ... | ISSP-S08



ASPRO2

A2P2

CHARA/SPICA + MIRCx/MYSTIC

Operation

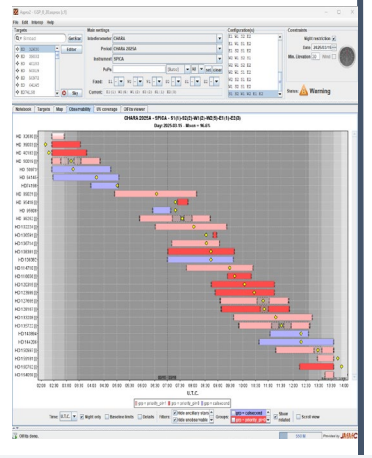
SPICA-DRS

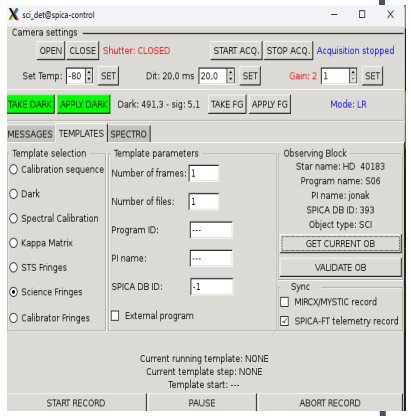
SPICA-QCS

R C - A P I

Atlanta CHARA Data Center

JMMC





Statistics and SPICA Pipeline

2024B: ISSP 25n, 5 eng night shared with CHARA, +15 CHARA nights, + 14 NOIRLab nights
2025B: ISSP 25n, 5 eng nights shared with CHARA, +12 CHARA nights, + 13 NOIRLab nights

Situation dominated by the difficulties with VIS+IR alignments, AO, and fringe quality in 2024

SPICA L1 data are automatically processed at the end of the night, including photometric and interferometric filtering (spicaft telemetry). Transfer to Nice for analysis.
MIRCX&MYSTIC L1 data are produced in Atlanta and adapted to spica post processing tools.
All L1 and L2 data for ISSP are manageable through our database (https://spicaweb.oca.eu)

Extension of the database to 'external' programs is in progress.
June/July 2025 installation of all the SPICA post processing tools in Atlanta for general users + documentation.

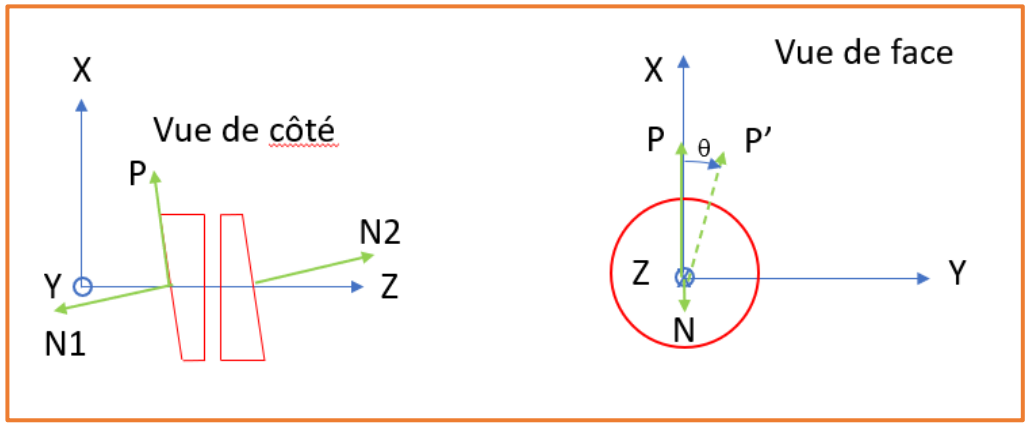
ISSP (2023B-2024A&B): 146 stars, ~300 single science observations

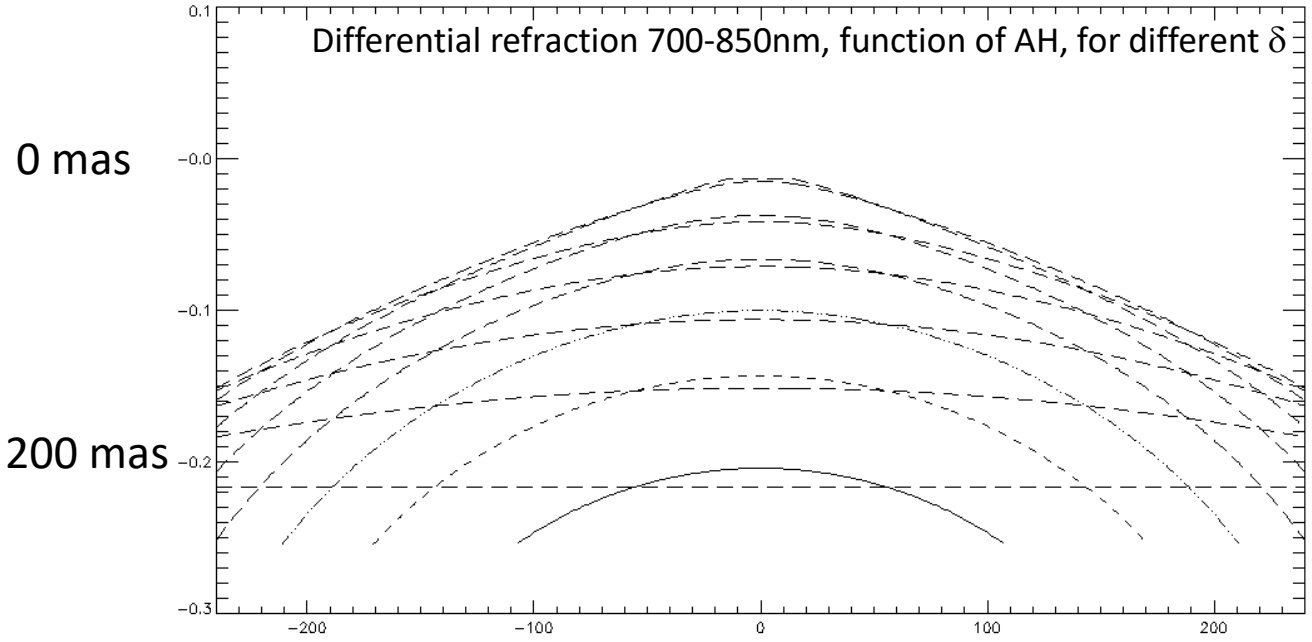
SPICA Technical improvements in 2024/2025

1. New OAP and fiber switchers in SPICA-FT/MIRC-X for AllInOne/ABCD rapid switch (10mn with STS)

2. New reliable stages for the compensation of polarization. Still some small changes from time to time maybe due to temperature fluctuations (? or something else) ➔ calibration before each run but maybe before each night would be better (~20mn)

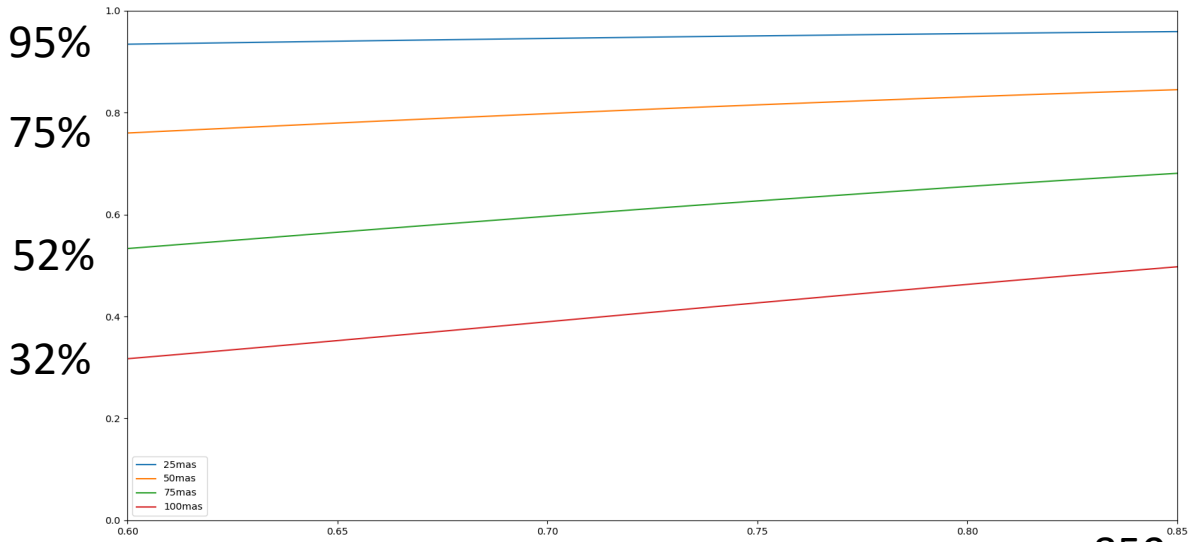
3. Changes of the tip/tilt stages for the IMG mirrors for blind compensation of the tip/tilt of the beams introduced by the Atmospheric Dispersion Compensators



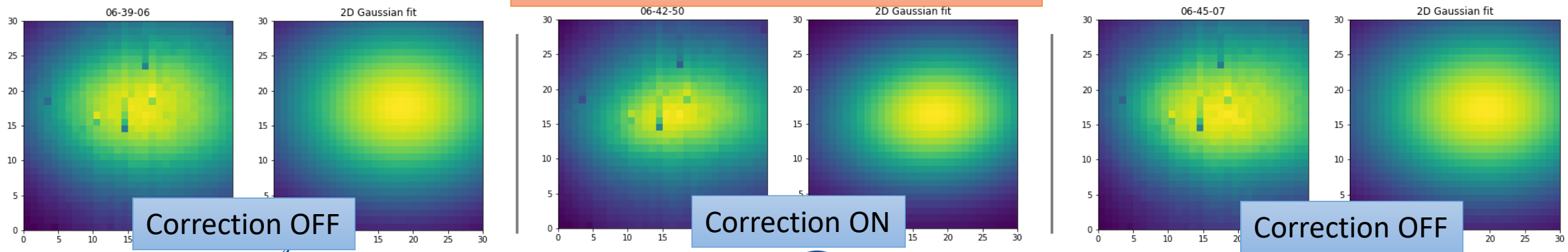


SPICA Correction of atmospheric refraction

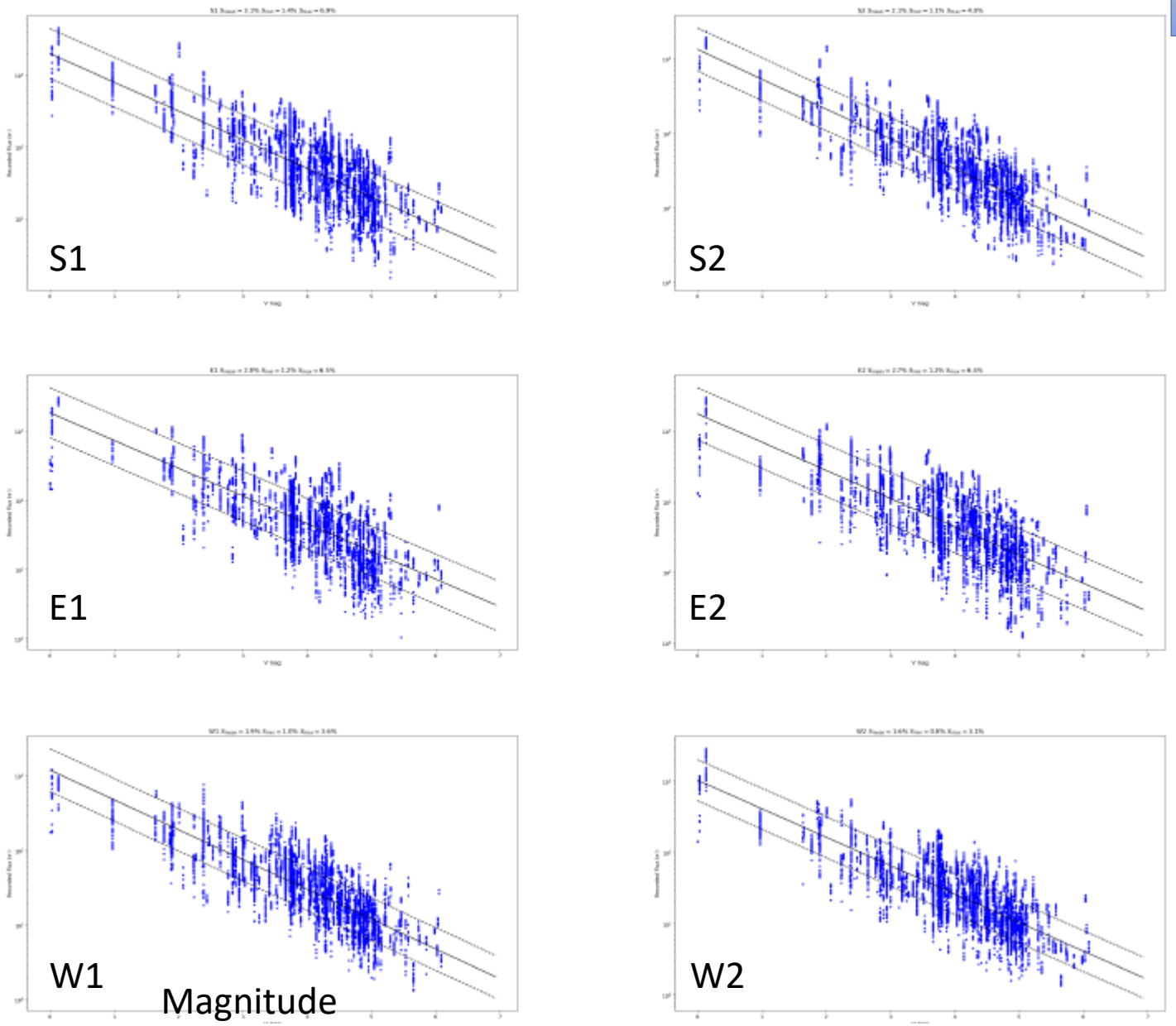
Percentage of injection as a function of λ



Result on sky HD135742 15 April 2025



Study of the transmission/injection



$$N_p = T_C \cdot T_{OA} \cdot Co \cdot S_{tel} \cdot \Delta\lambda \cdot DIT \cdot 10^{-0.4m} \cdot \Phi_0 \cdot Q$$

$T_C = 0.005$: the instrumental transmission
$Co = 0.02$: the coupling efficiency (0.4 x Strehl=0.05)
$T_{OA} = 0.765$: the transmission of the adaptive optics

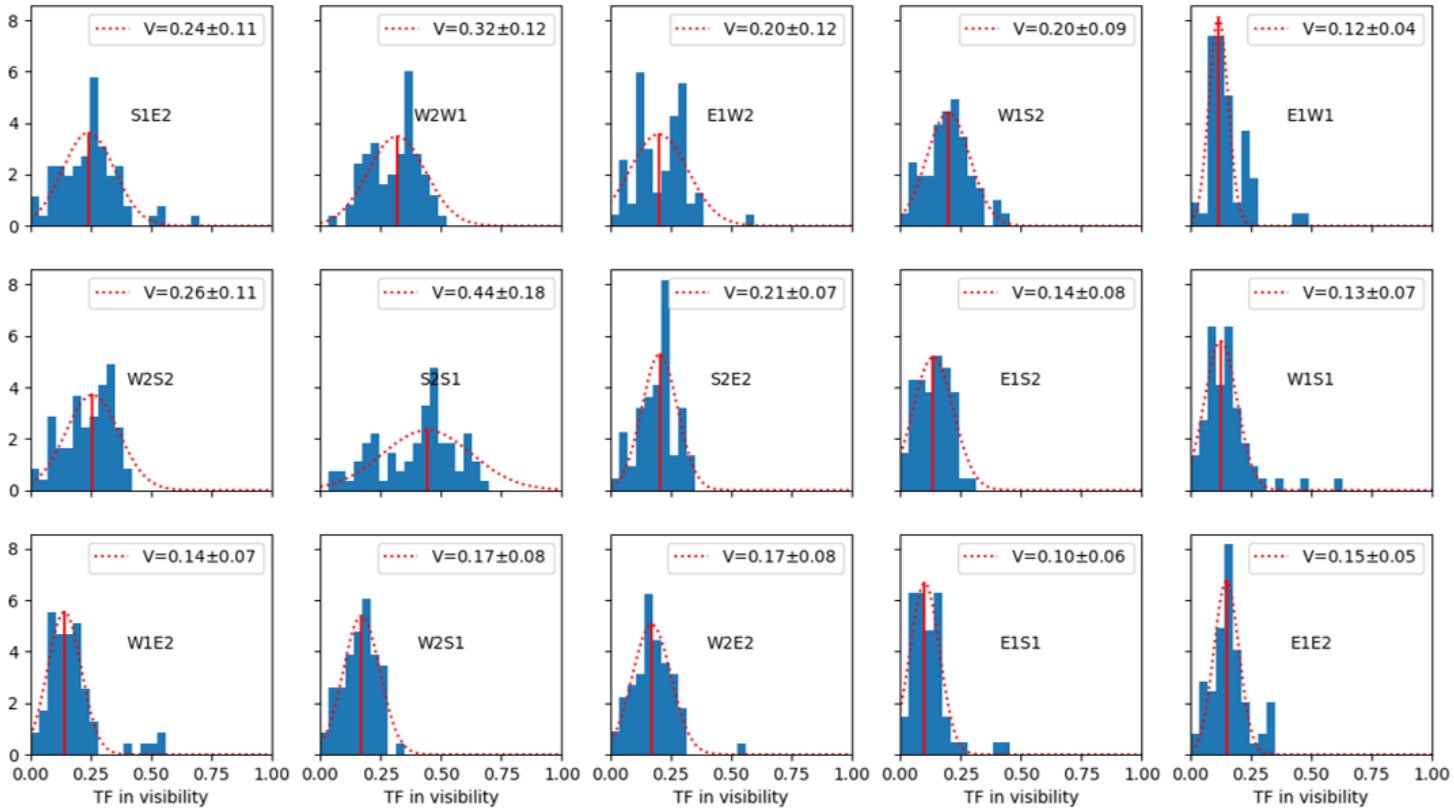
<Strehl Ratio> estimation
<SR> = 5-6%

Expected performance was 20-25%
In October 2024, with many efforts and good conditions 10-18% has been reached.

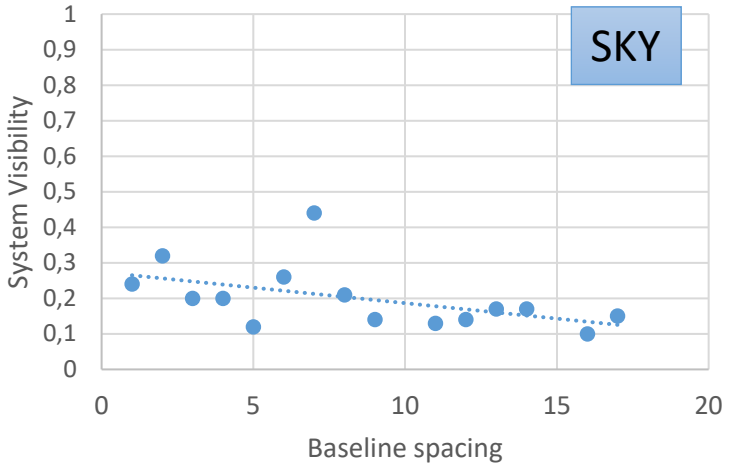
<SR> = 10-15% is more representative of the reality unfortunately

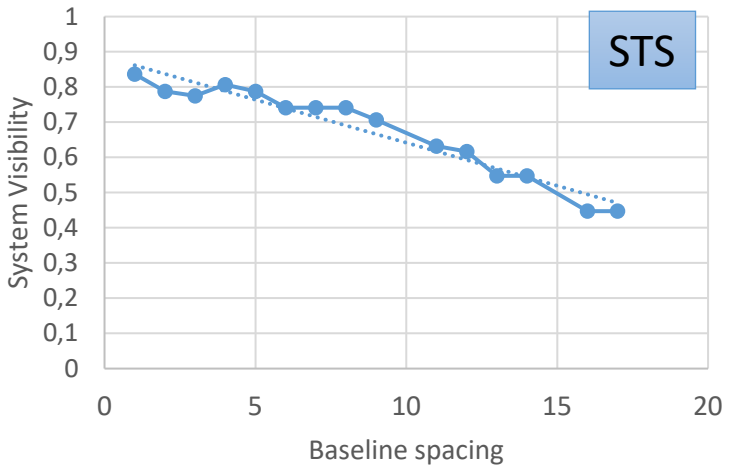
Gain in Tc with the recoatings?

Analysis of the system visibility

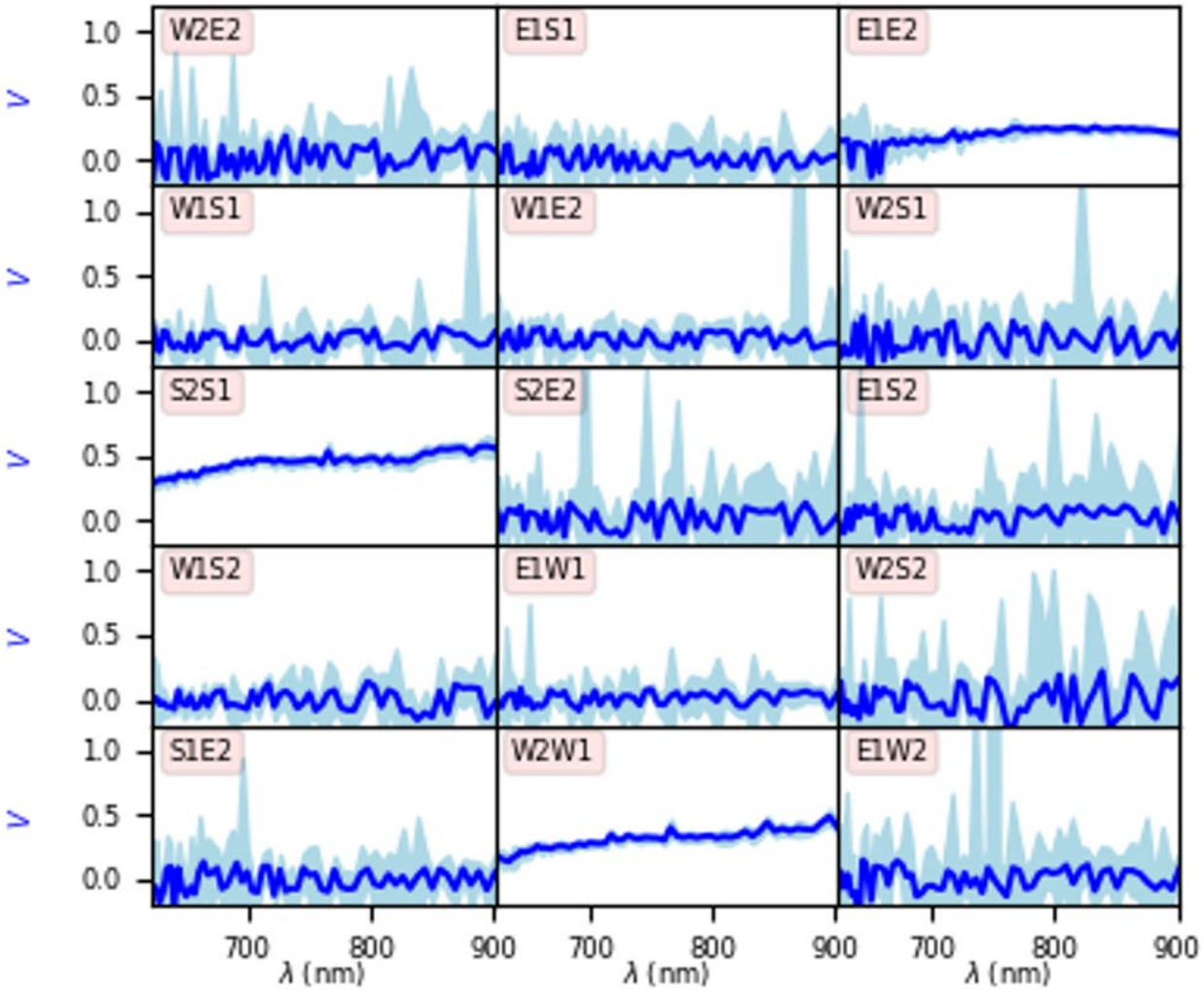


Distribution of system visibility for 2024





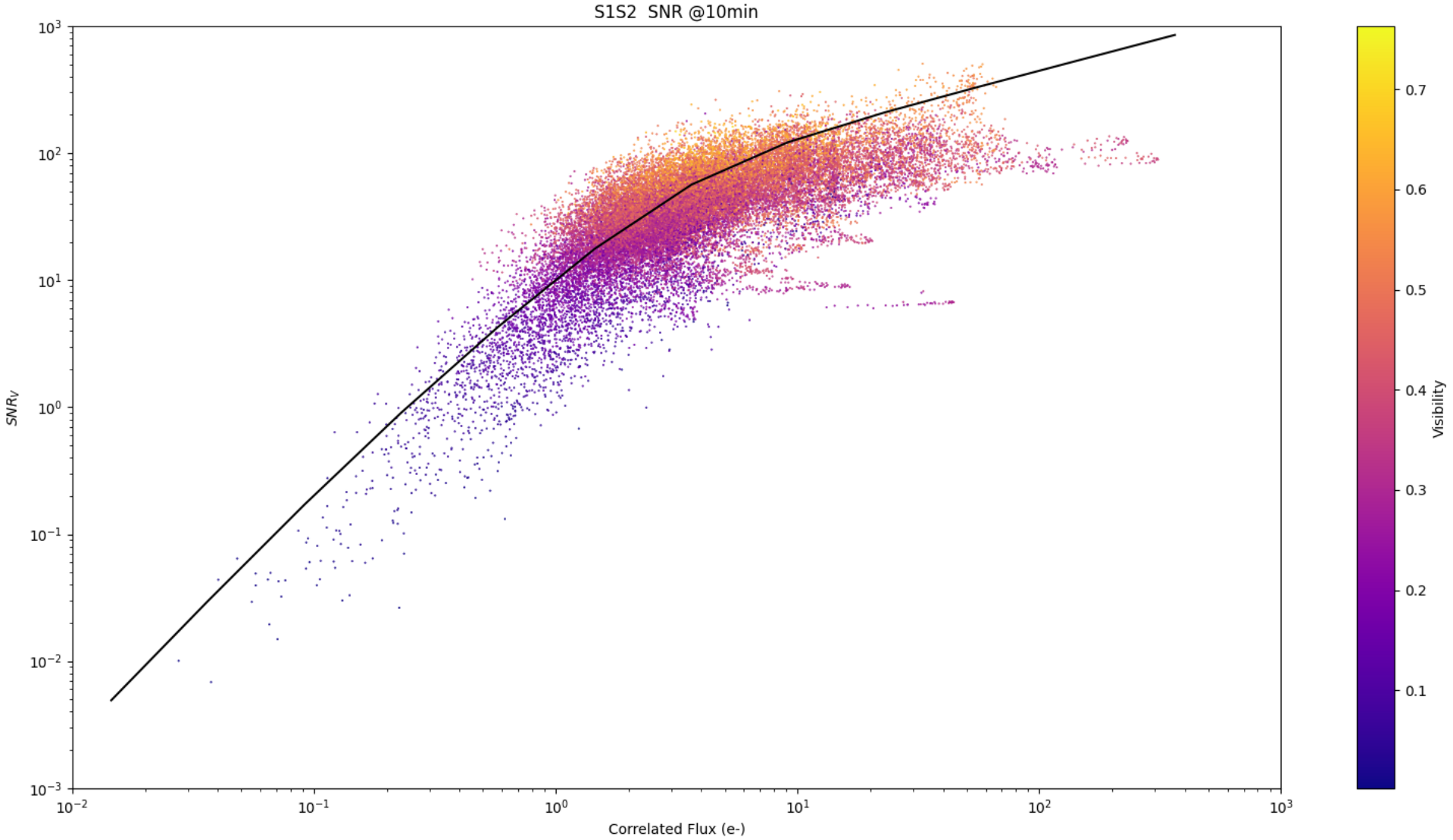
Improvement in 2025? Tests on HD177724 on March 23



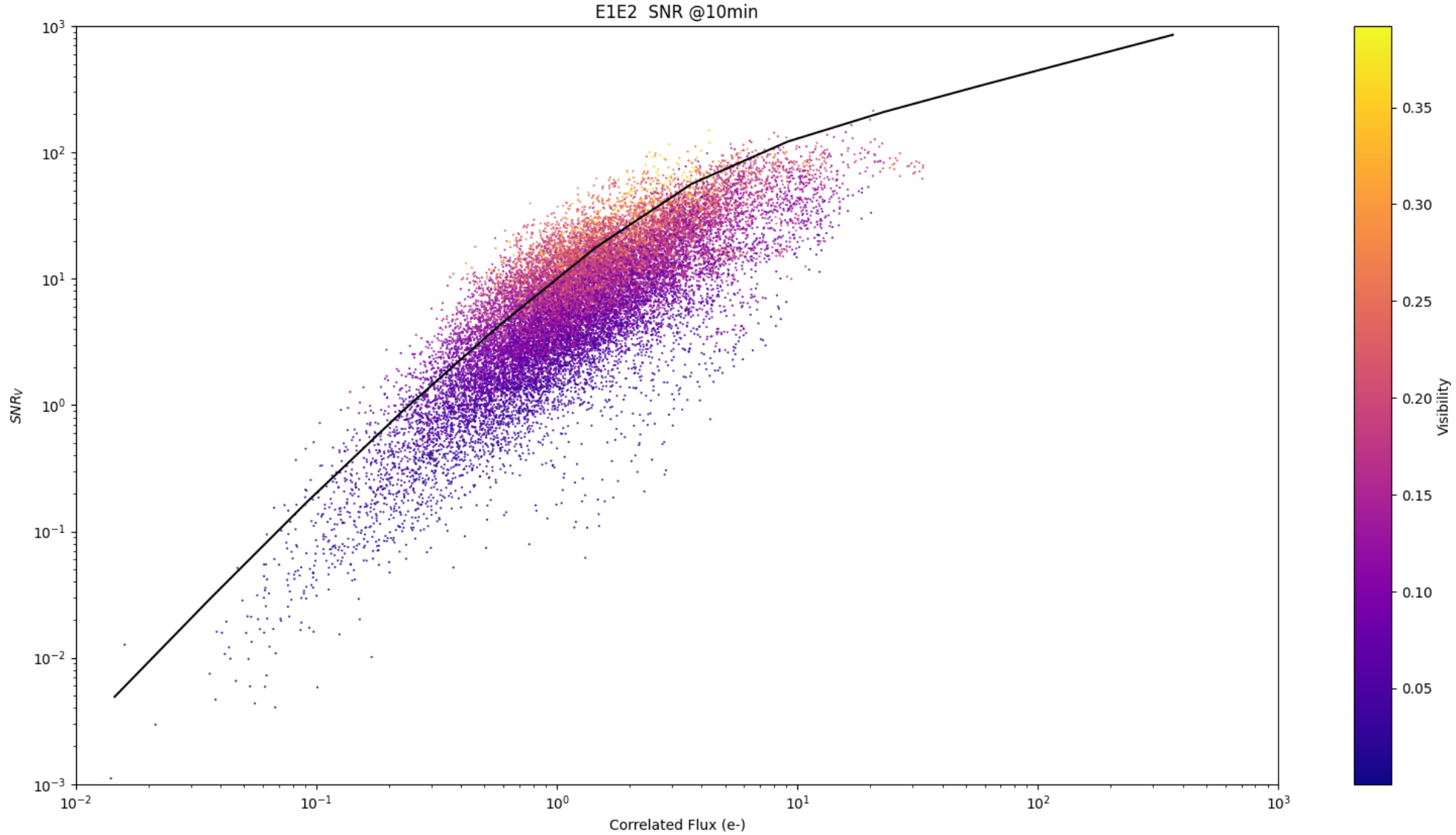
Only three usable baselines
Estimation of system visibility:
S1S2: 0,45 (instead of 0,44)
E1E2: 0,20 (instead of 0,15)
W1W2: 0,36 (instead of 0.32)

Not yet convincing (but mystic GDT tracking).
Nothing possible in April unfortunately

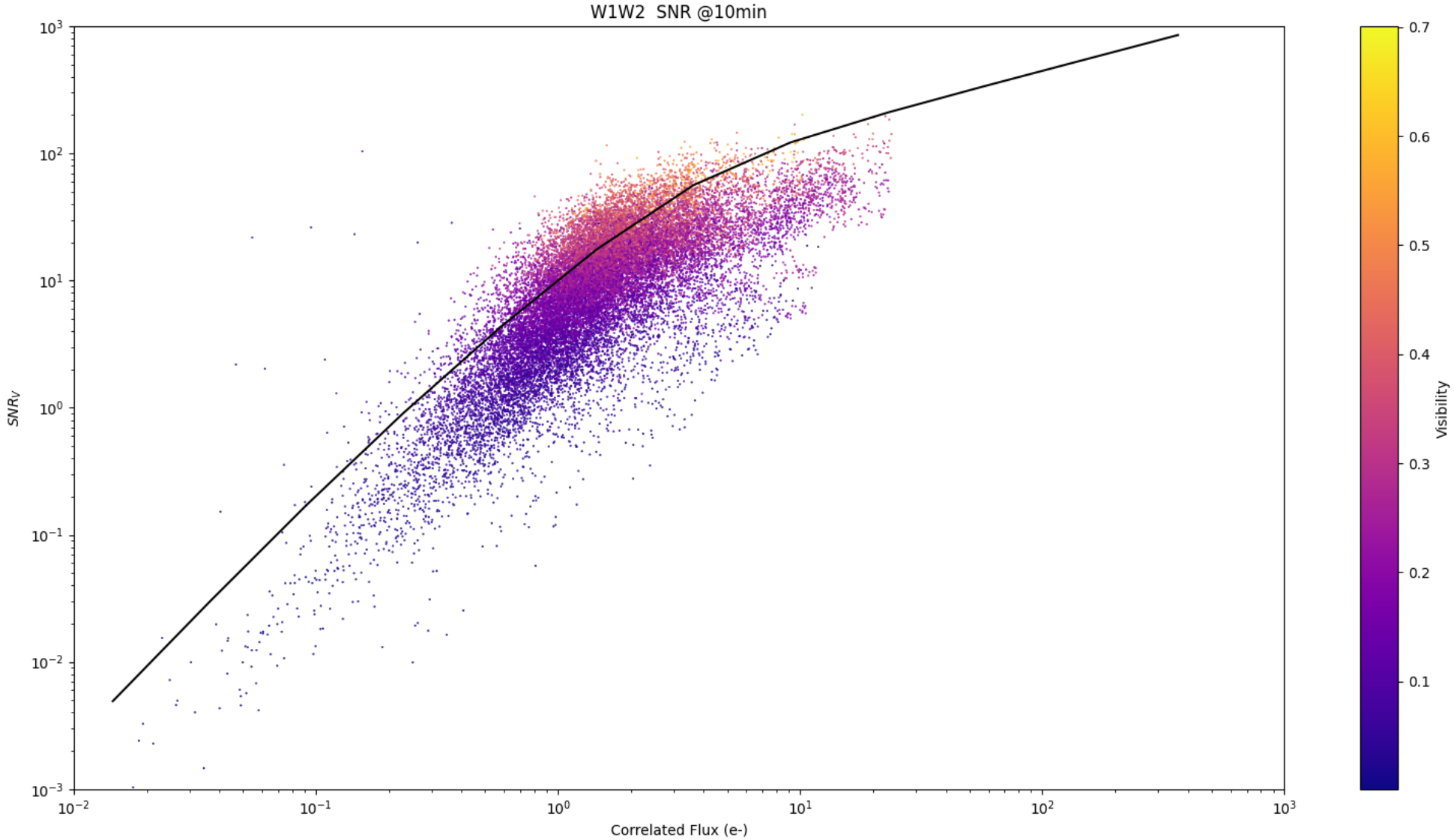
Noise model (S1S2 statistics)



Noise model (E1E2 statistics)

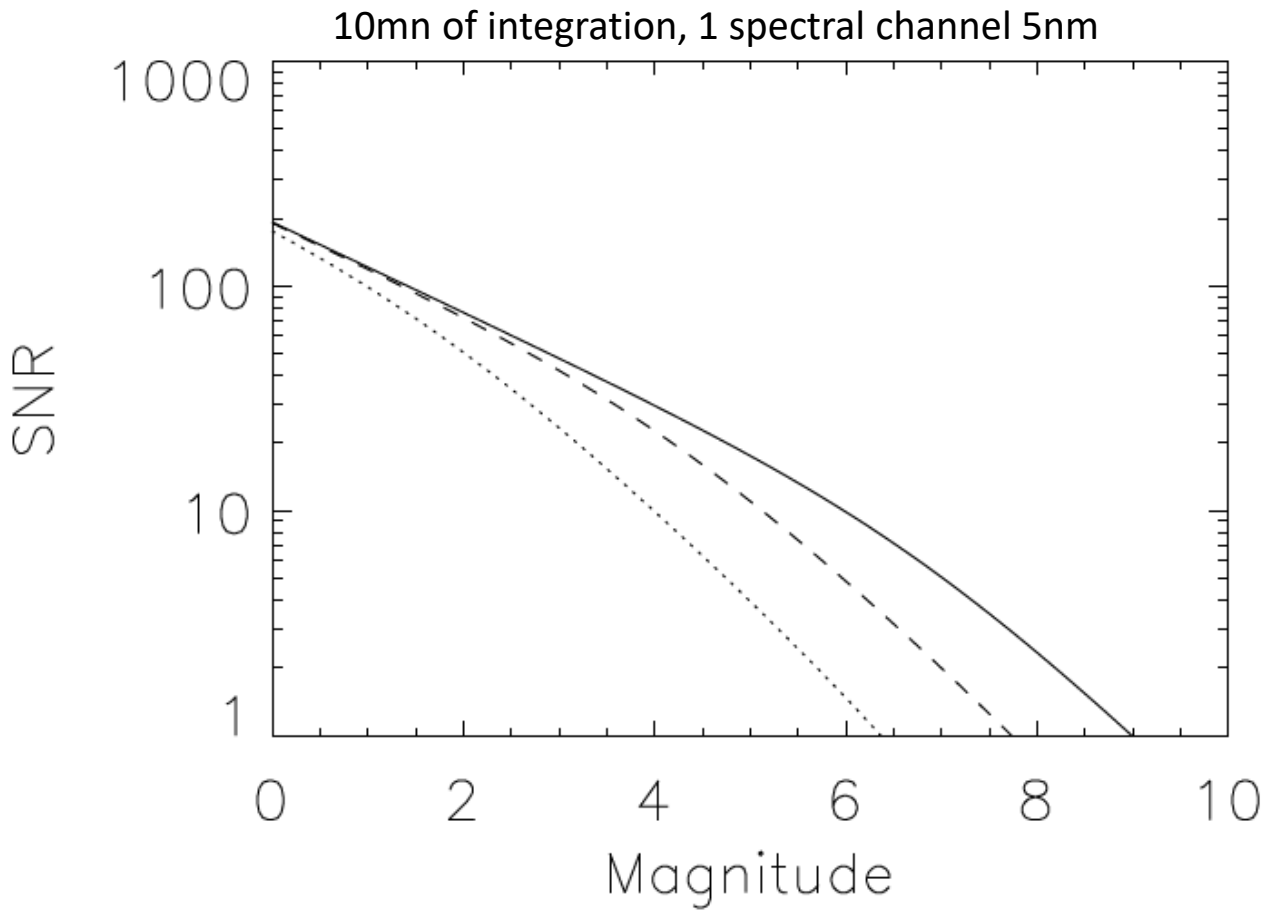


Noise model (W1W2 statistics)



Estimation of performance LR mode

Hypothesis: SR=15%, Vinst=0.6, Tc=1%, Vobj=0.1



ExpTime=0.02s

ExpTime=0.2s

ExpTime=2s

SPICA-FT is critical

SPICA-FT situation

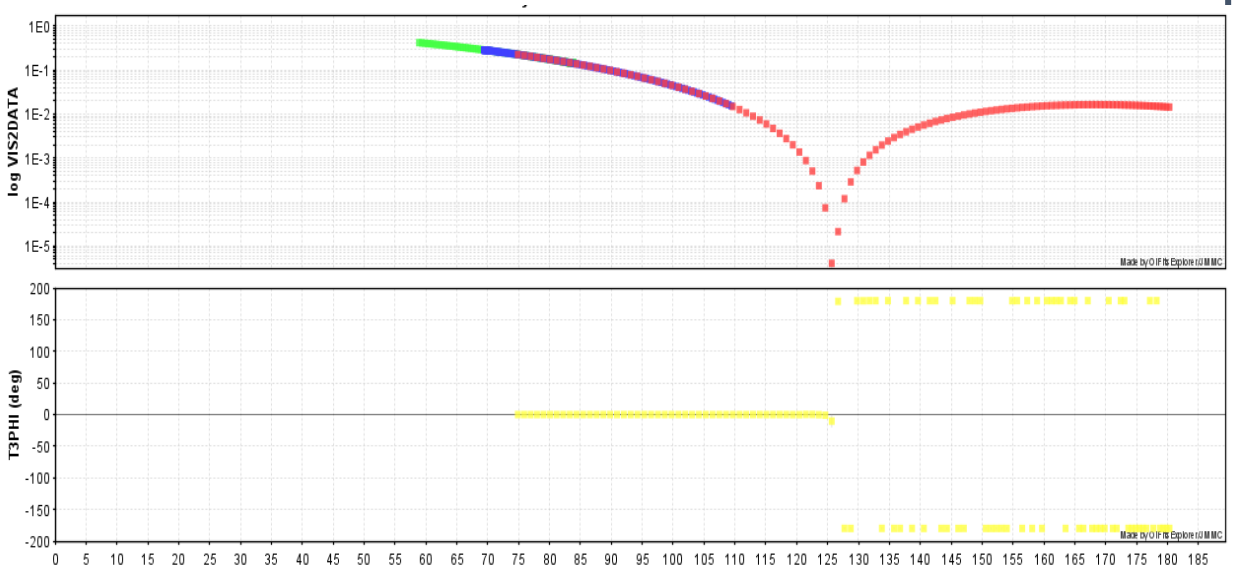
Group delay and Phase Delay tracking at 6T in H band, with AllInOne and ABCD have been demonstrated.
Operation is not user-friendly for the moment.

Limitations identified when object is resolved.

Implementation of the reference vectors (Lacour+2019) build on closure phases + numerical simulator (Arnaud Caci).
Formalism much more complex at 6T (20 closures) than at 4T (4 closures). (Φ –Φref) could be locked to 0!

Demonstration on sky in April 2025

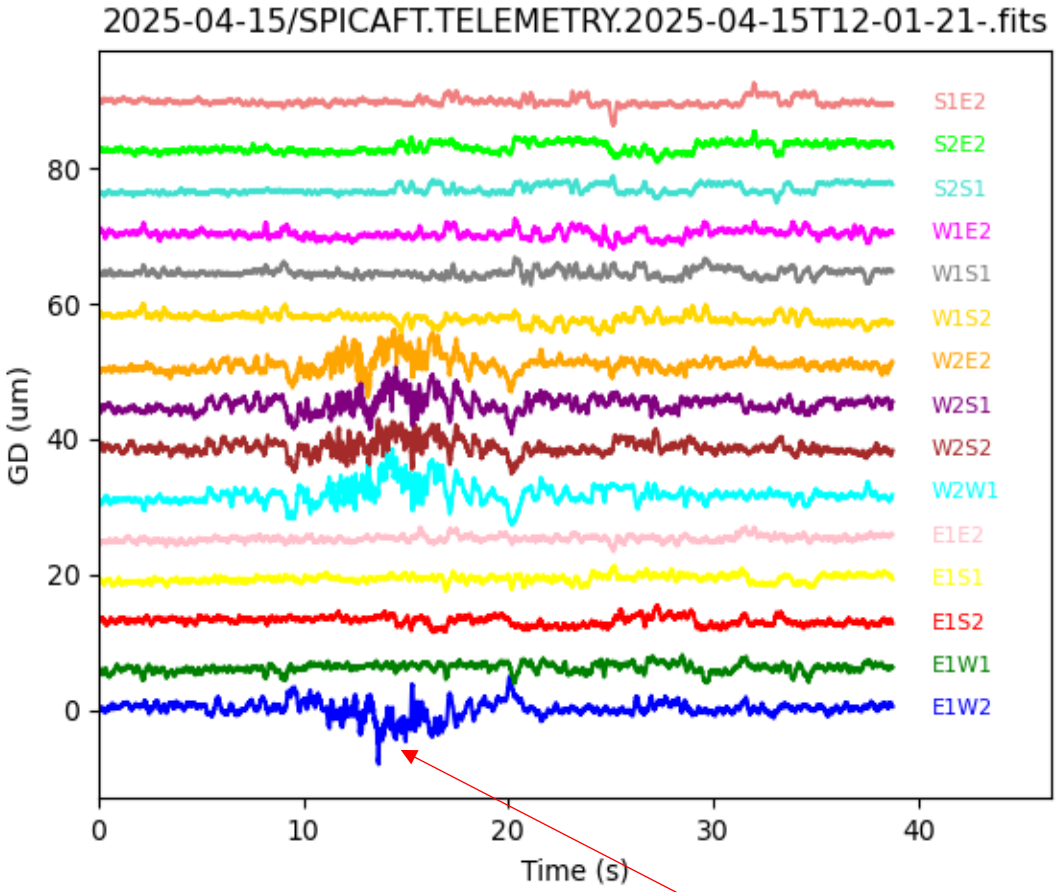
SPICA-FT OPD controller is ready for Group Delay and Phase Delay Tracking even on resolved objects; work on user-friendly interface is necessary

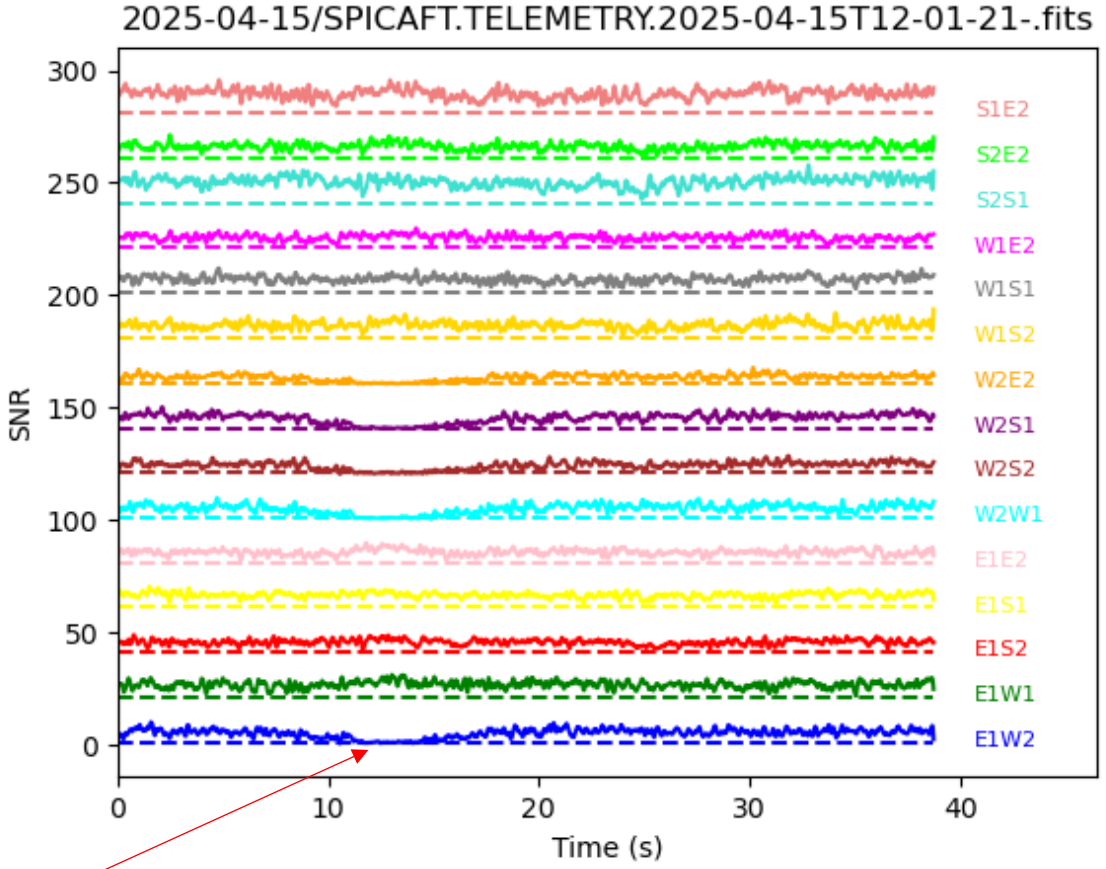


$$\Phi_{\text{ref}} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \Theta_{123} \\ \Theta_{124} \\ \Theta_{125} \\ \Theta_{126} \\ \Theta_{134} \\ \Theta_{135} \\ \Theta_{136} \\ \Theta_{145} \\ \Theta_{146} \\ \Theta_{156} \end{pmatrix}, \begin{pmatrix} 0 \\ -\Theta_{123} \\ -\Theta_{124} \\ -\Theta_{125} \\ -\Theta_{126} \\ 0 \\ 0 \\ 0 \\ 0 \\ \Theta_{234} \\ \Theta_{235} \\ \Theta_{236} \\ \Theta_{245} \\ \Theta_{246} \\ \Theta_{256} \end{pmatrix}, \begin{pmatrix} \Theta_{123} \\ 0 \\ -\Theta_{134} \\ -\Theta_{135} \\ -\Theta_{136} \\ 0 \\ -\Theta_{234} \\ -\Theta_{235} \\ -\Theta_{236} \\ 0 \\ 0 \\ 0 \\ \Theta_{345} \\ \Theta_{346} \\ \Theta_{456} \end{pmatrix}, \begin{pmatrix} \Theta_{124} \\ \Theta_{134} \\ 0 \\ -\Theta_{145} \\ -\Theta_{146} \\ \Theta_{234} \\ 0 \\ -\Theta_{245} \\ -\Theta_{246} \\ 0 \\ -\Theta_{345} \\ -\Theta_{346} \\ 0 \\ 0 \\ \Theta_{456} \end{pmatrix}, \begin{pmatrix} \Theta_{125} \\ \Theta_{135} \\ \Theta_{145} \\ 0 \\ -\Theta_{156} \\ \Theta_{235} \\ \Theta_{245} \\ 0 \\ -\Theta_{256} \\ \Theta_{345} \\ 0 \\ -\Theta_{356} \\ 0 \\ -\Theta_{456} \\ 0 \end{pmatrix}, \begin{pmatrix} \Theta_{126} \\ \Theta_{136} \\ \Theta_{146} \\ \Theta_{156} \\ 0 \\ \Theta_{236} \\ \Theta_{246} \\ \Theta_{256} \\ 0 \\ \Theta_{346} \\ \Theta_{356} \\ 0 \\ \Theta_{456} \\ 0 \\ 0 \end{pmatrix}$$

Best OB : 2025-04-15T12-01-21

HD141680 – 0.4mas



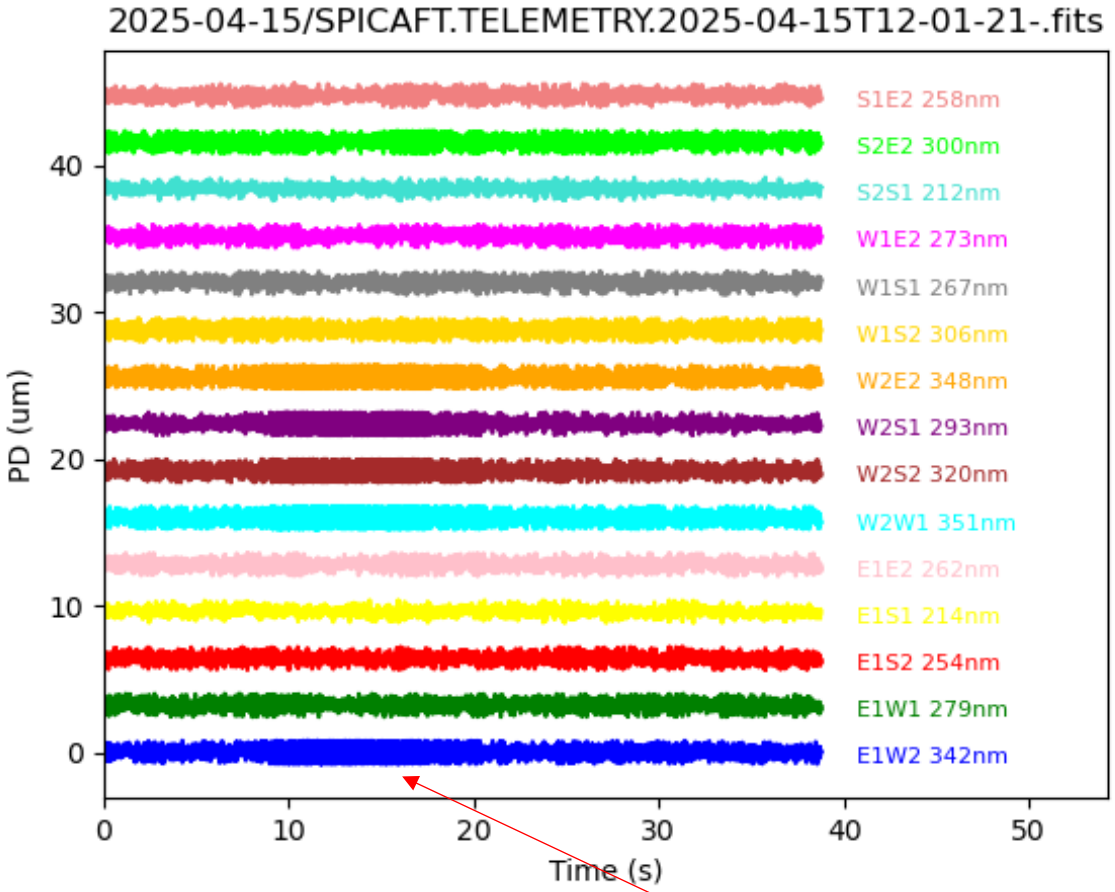


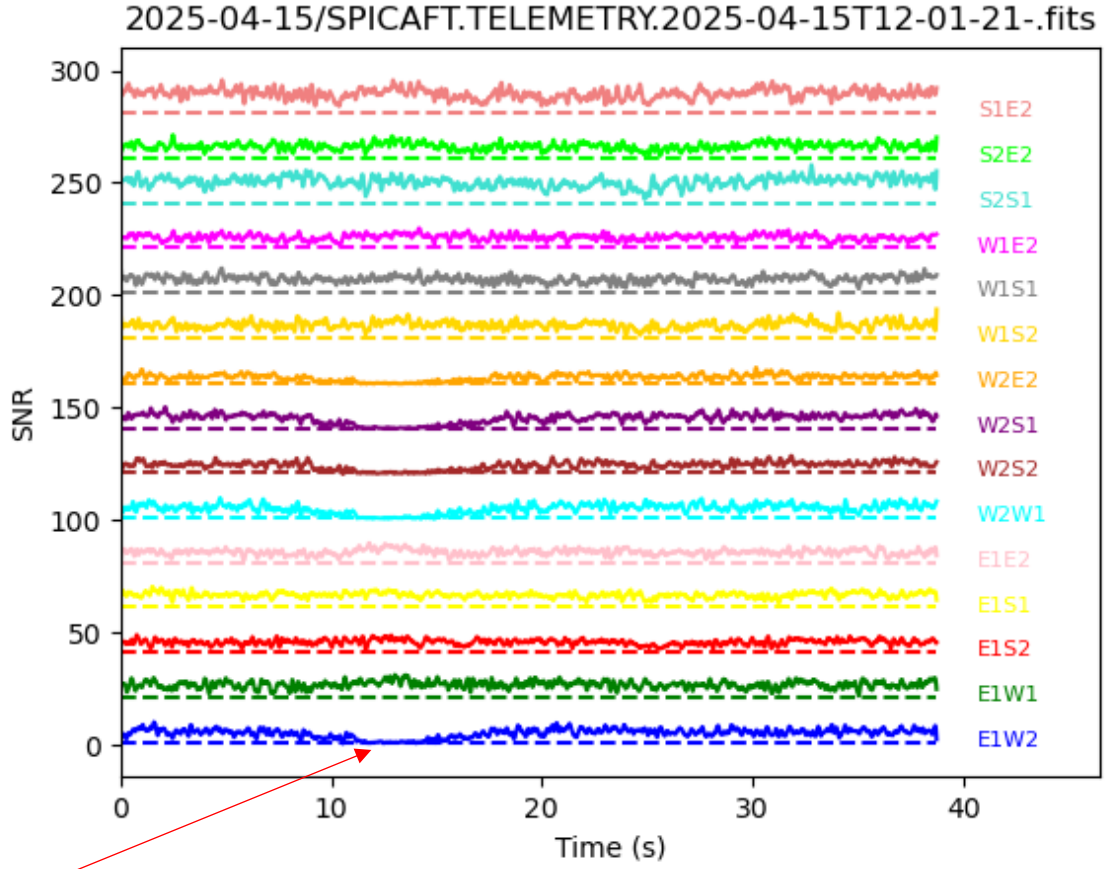
=> Dashed lines correspond to SNR thresholds

Bad SNR sequence => Bad GD

Best OB : 2025-04-15T12-01-21

HD141680 – 0.4mas

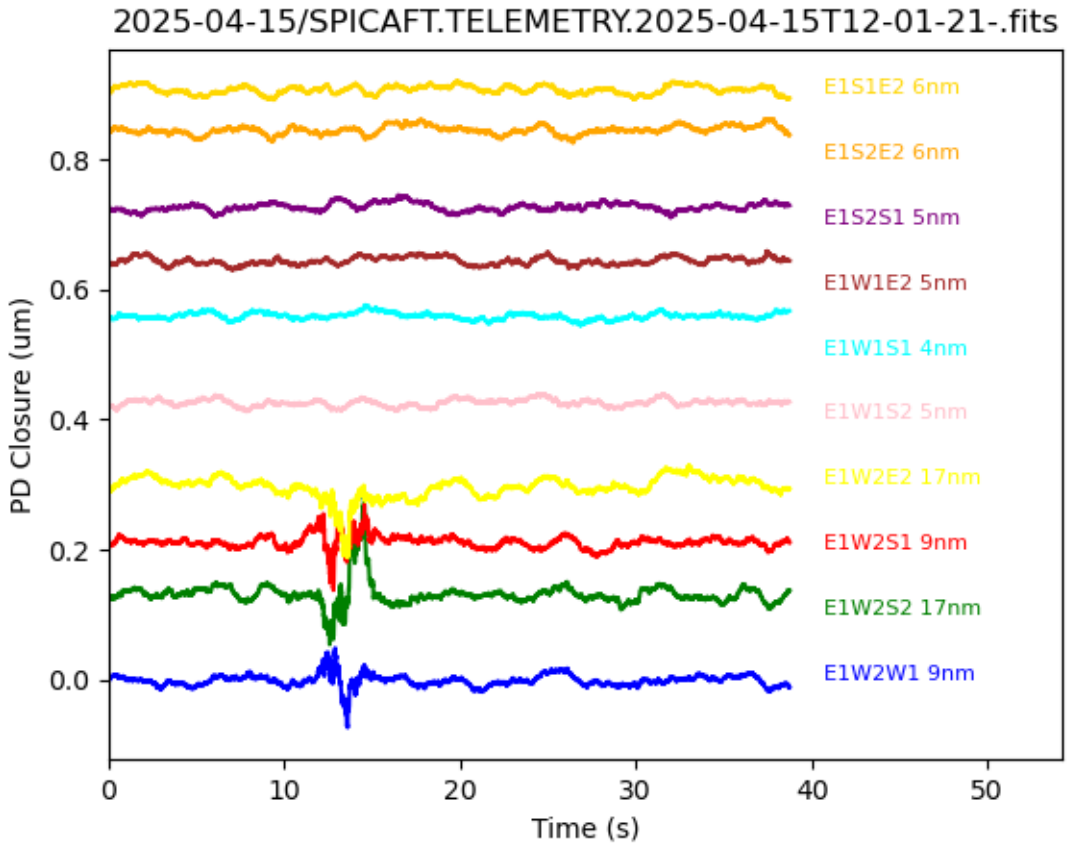


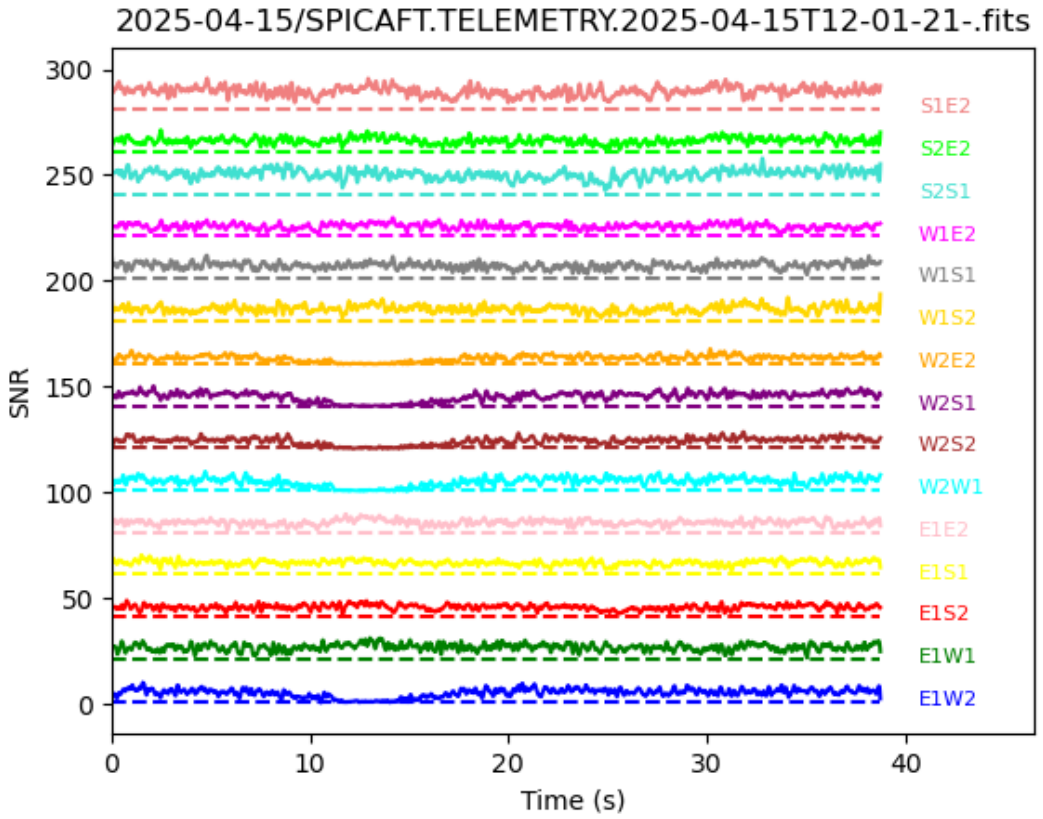


Bad SNR sequence => Bad GD => Bad PD

Closure Phase behavior

HD141680 – 0.4mas





- Closure Phase stable when SNR > threshold

PSAUM: seeing monitor in development

Figure 1: PSAUM installed on Calern Observatory in France.

10cm telescope observing the polar star
Measurement @500nm of seeing, Fried parameter, isoplanatic angle, scintillation, and coherence time.

Installation foreseen in August 2025 on a Pillar, north of the Workshop platform