Update on SPICA & ISSP

Denis Mourard – Observatoire de la Côte d'Azur - with

Stellar Parameters and Images with a Cophased Array team,

Interferometric Survey of Stellar Parameters team,

and **CHARA** + JMMC team

SPICA in very brief

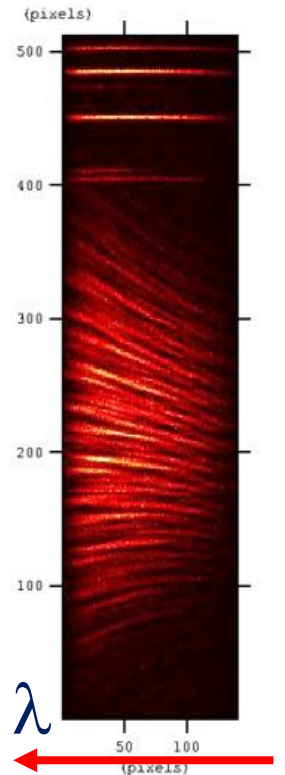SPICA team: C. Bailet, P. Bério, J. Dejonghe, P. Geneslay, D. Lecron, F. Morand, S. Rousseau, D. Salabert

- ➢ A H-band 6T fringe tracking system aiming at performing group delay and phase delay tracking of the fringes.
- ➢ A good model and good correction of the chromatic OPD between H/K and R (LDC/VLDC/DDL)
- ➢ A All-In-One 6T combiner (600-900nm) with 3 dispersion modes and spatial filtering with monomode fibers

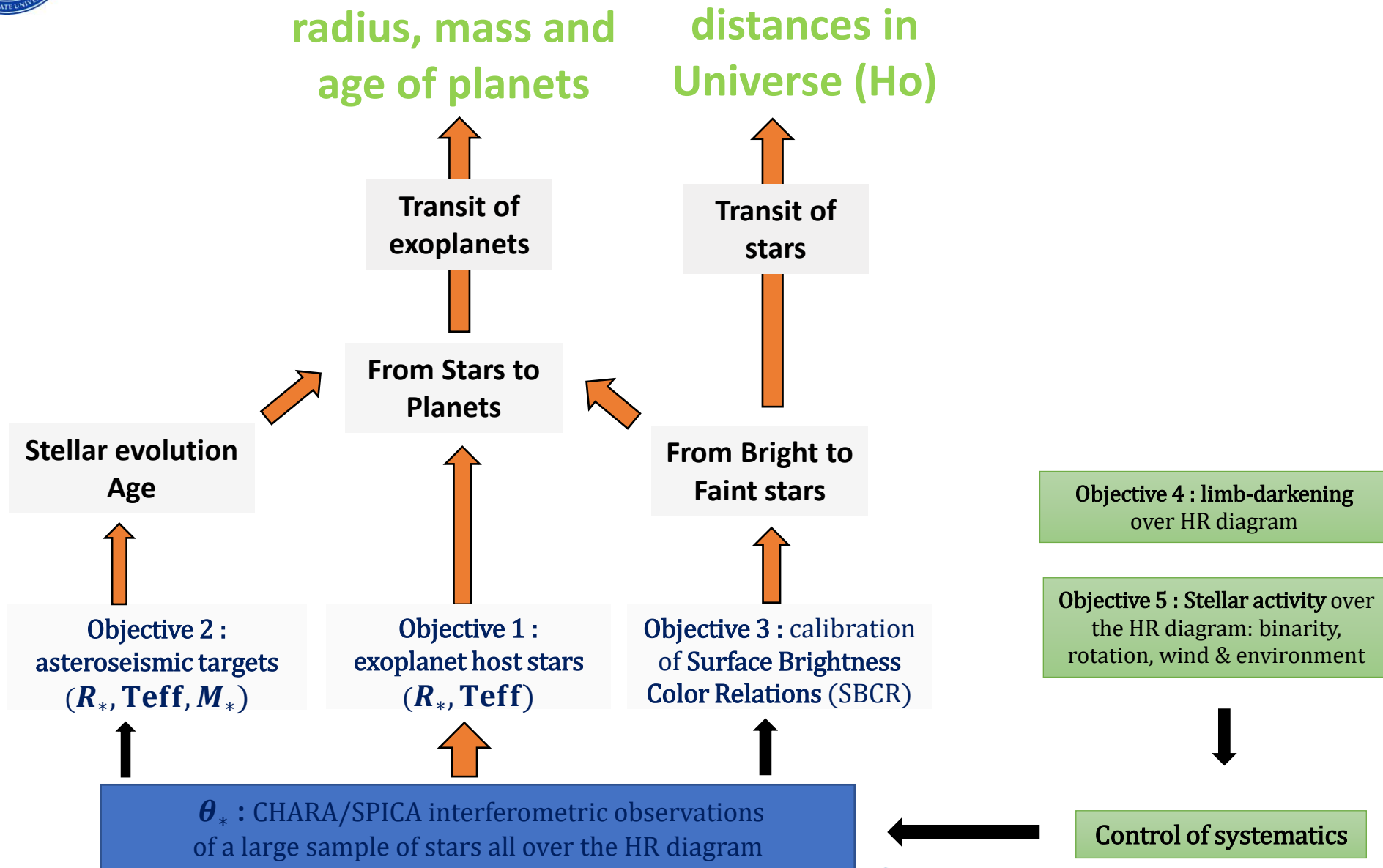*SNR calculator based on FRIEND calibration (Martinod+2018), CHARA-AO hypothesis (SR=25%), SPICA estimations (V=0.9)*

MagLim: V^2: SNR=10, 10mn of integration, for one spectral channel
Vdiff: [SNR=10, $\sigma\phi$<5°], V^2=0.6 in the reference channel, 30mn of integration, for one spectral channel

MODES	Nb of SpCh	SpCh	Spectral Band	MagLim V^2=0.6	MagLim V^2=0.6 + FT	MagLim Vdiff	MagLim Vdiff+FT
LR: R=140	60	3-7 nm	300nm	8.5	11.5		
MR: R=4400	500	0.17nm	85nm			5.5	9.5
HR: R=13000	500	0.06nm	29nm			4.5	8.5

λ

Interferometric Survey of Stellar Parameters

radius, mass and age of planets

distances in Universe (Ho)

Transit of exoplanets

Transit of stars

Strong links with:
- ESA/PLATO mission
- Araucaria program

From Stars to Planets

Stellar evolution Age

From Bright to Faint stars

Objective 4 : limb-darkening over HR diagram

Objective 2 : asteroseismic targets (R_*, Teff, M_*)

Objective 1 : exoplanet host stars (R_*, Teff)

Objective 3 : calibration of **Surface Brightness Color Relations** (SBCR)

Objective 5 : **Stellar activity** over the HR diagram: binarity, rotation, wind & environment

θ_* : CHARA/SPICA interferometric observations of a large sample of stars all over the HR diagram

Control of systematics

SPICA

The ISSP science team

➢ Roxanne Ligi: 3-year postdoc (1/12/2022) – exoplanet host stars

➢ Mathieu Vrard: 3-year postdoc (1/11/2022) – interferometry and asteroseismology

➢ Romina Ibañez-Bustos: 3-year postdoc(1/04/2023) –SBCR

➢ Nayeem Ebrahimkutty: PhD (1/07/2023) – Limb darkening

➢ Juraj Jonak: PhD (1/12/2022) – binaries and stellar masses
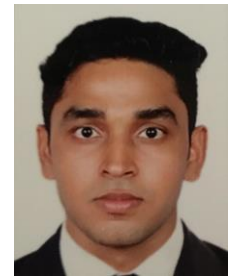
Associated coI of the survey: Orlagh Creevey (astero-dwarfs), Sébastien Deheuvels (astero-giants), Armando Domiciano (rotating stars), Nicolas Nardetto (SBCR), Markus Wittkowski (winds and environnements), and Karine Perraut
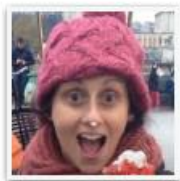
SPICA

SPICA-DB and Night Scheduling Software
JMMC collaboration

- Based on SPICA/ISSP catalog
- Query of existing potential targets with filters
- Search for primary calibrators (internal list) and secondary ones (JSDC)
- Ideal for large programs: management of priorities, selection of small declination ranges, share of calibrators

- Send all required information to ASPRO2 for the night management

- ASPRO2 communicates with SPICA through A2P2

SPICA

SPICA 2023 Achievements

- All 15 fringes simultaneously with MIRCx and MYSTIC (June 23)

- Implementation of chromatic OPD validated in September 2023

- Organisation of night based on 'survey mode' ➜ one data point every 30mn (use of ASPRO2+A2P2 connected to SPICA OS)

- End of night automatic pipeline up to L0 and L1 data (uncalibrated ➜ OiDB)

- Calibration pipeline validated (work for SPICA, MIRCx and MYSTIC data)

- But:
  - AO correction (TelAO) and Image quality (LABAO) have been very variable and of overall poor quality ➜ poor injection ➜ limited sensitivity
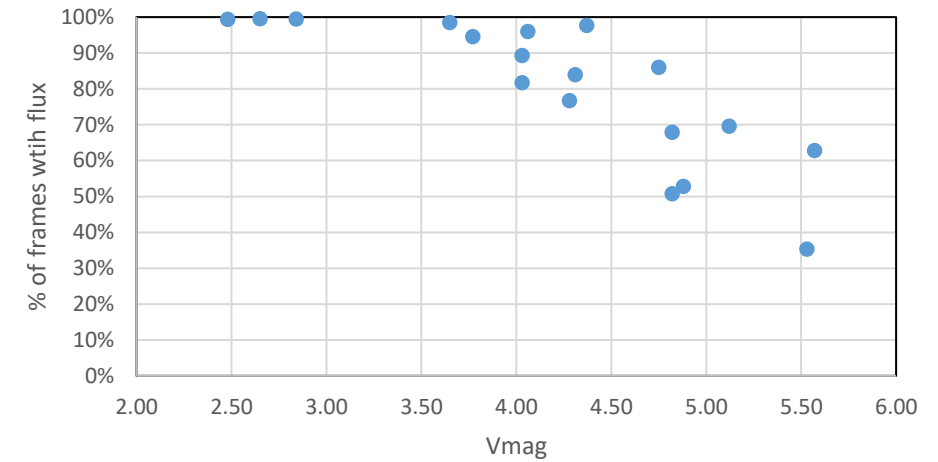 - OPLE issue ➜ very poor instrumental visibility on sky

SPICA

Current situation of injection as measured on Sep 26

Photometric flag if the mean flux in the photometric channel is < 3 σ_{sky}
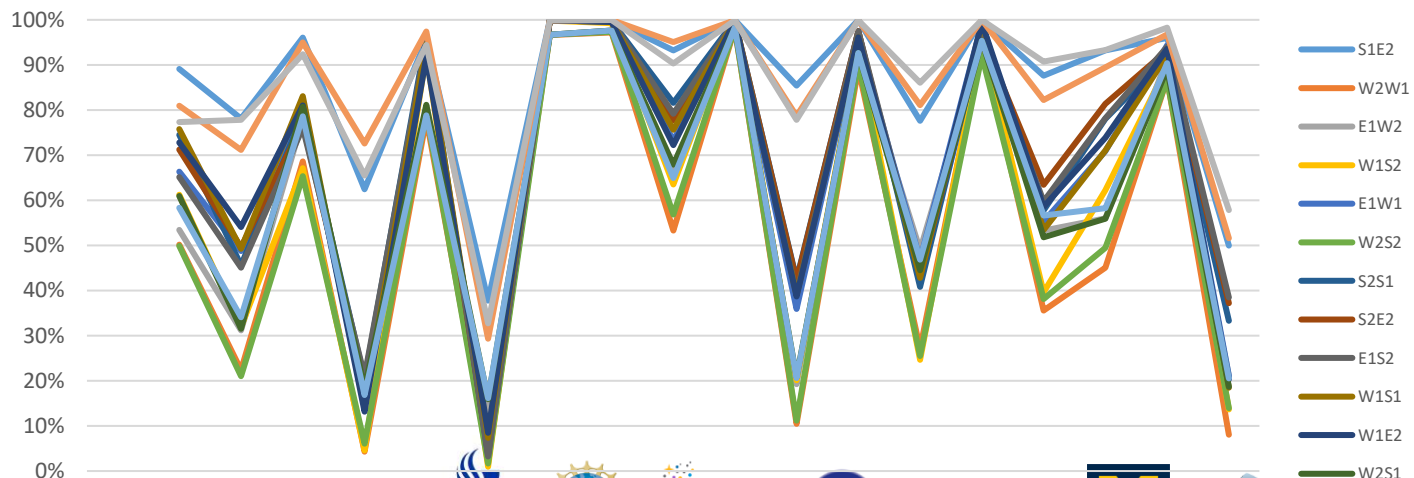*For each baseline, the frame is considered if both PhotomFlag are FALSE*
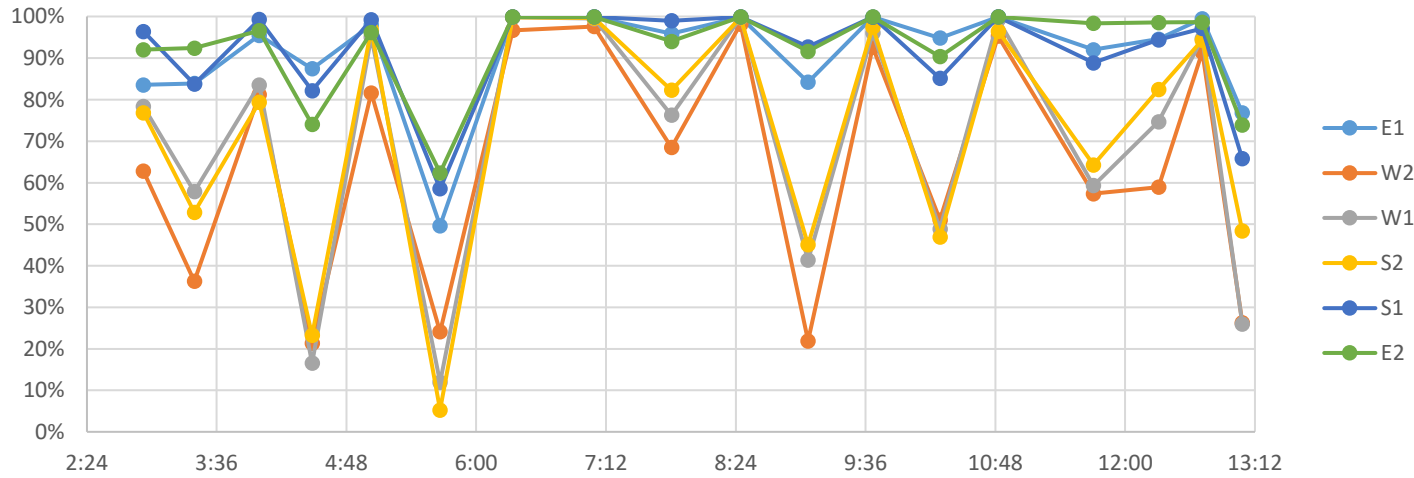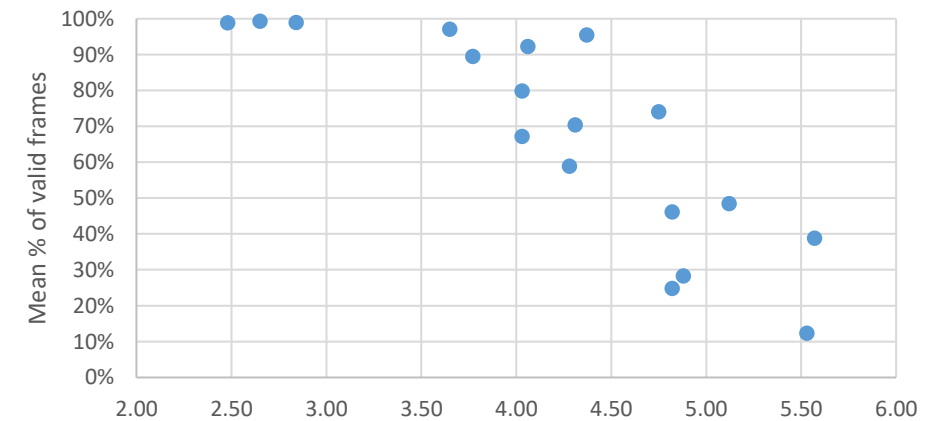
Difficulty with Alignment process, AO performance and Image quality
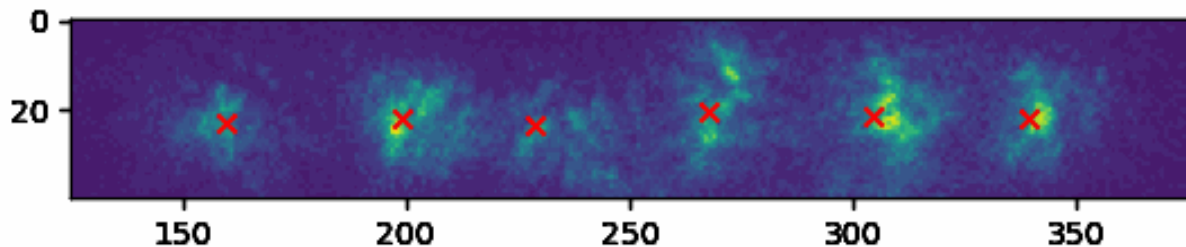
April, 10 2023 HD184006 injected flux

HD87901, Dec 2023, r0 around 8cm

Flux E1 = 106926 +/- 25916

Flux W2 = 36468 +/- 28361

~~Flux W1 = 517 +/- 1493~~

Flux S2 = 24012 +/- 11437
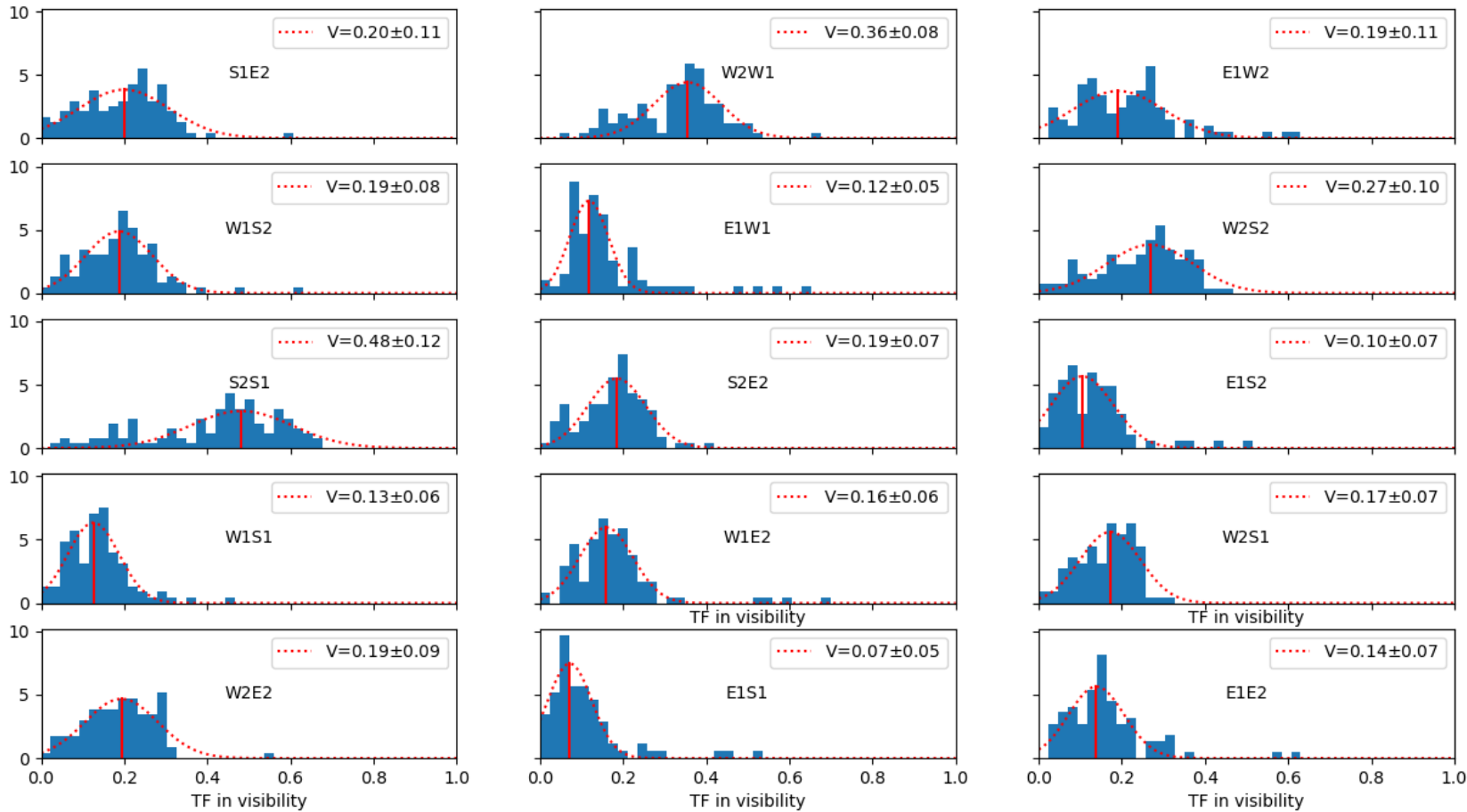
Flux S1 = 30198 +/- 20333

Flux E2 = 194001 +/- 49489

Strehl Ratio closer to 8% then the expected 25%. Loss of flux by a factor ~10 → 2.5mag
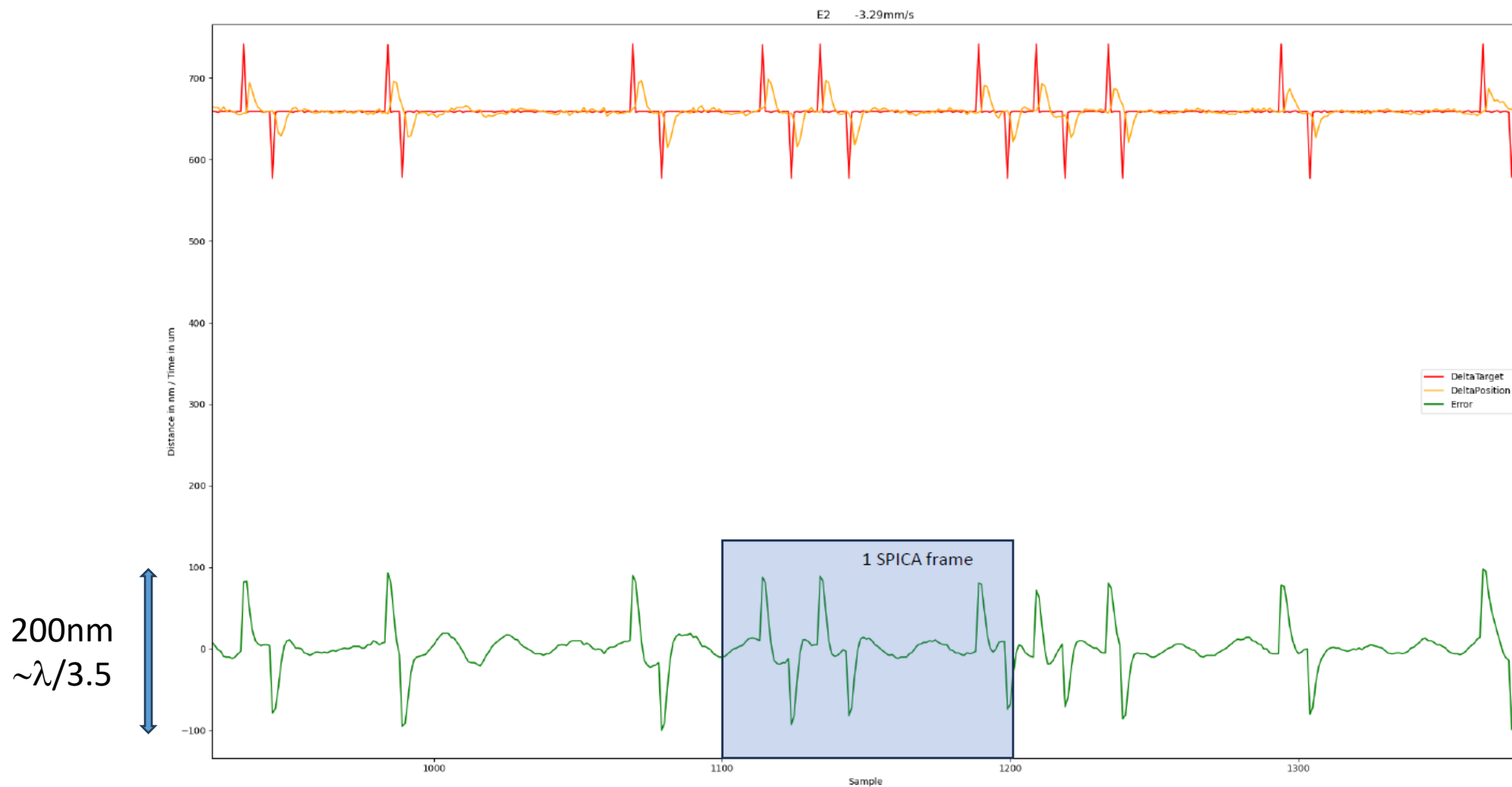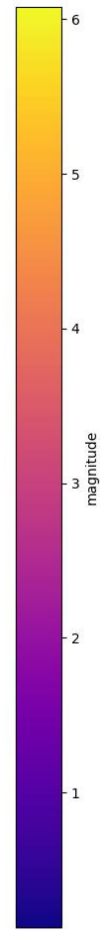
SPICA

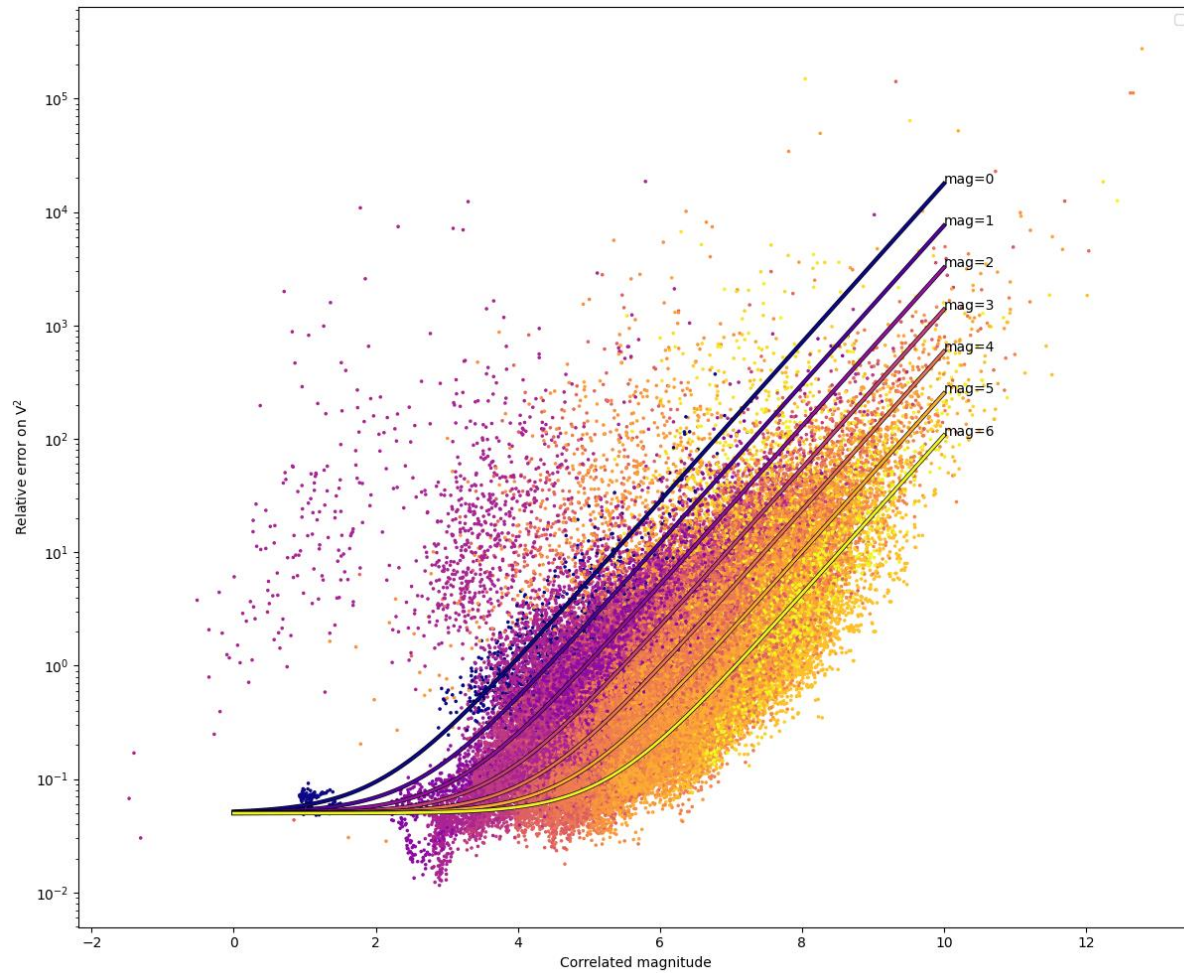# Difficulties with the Transfer Function

Important oscillations in the optical delay lines. Investigations under progress.

$<V>=0.19 \rightarrow <V^2> < 0.04 \rightarrow$ a loss in SNR by a factor 25!

OPLE issue

E2 PZT ON V=3.3mm/s zoom

Statistics of noise model on SKY

Model fitting
errV2 = 0.05+10 ^(0.7*magCorr-2.75-0.37*mag)

SPICA

SPICA-VIS and STS

- Difficulties all along the year with variable visibility, sometime very poor on some beams.

- A lot of noise and vibrations on the metrology table ➔ isolation, damping of vibrations

- The old LabTT ANDOR camera was ON with FAN ON and venting hot air very close to the SPICA beam

- Situation highly improved in February
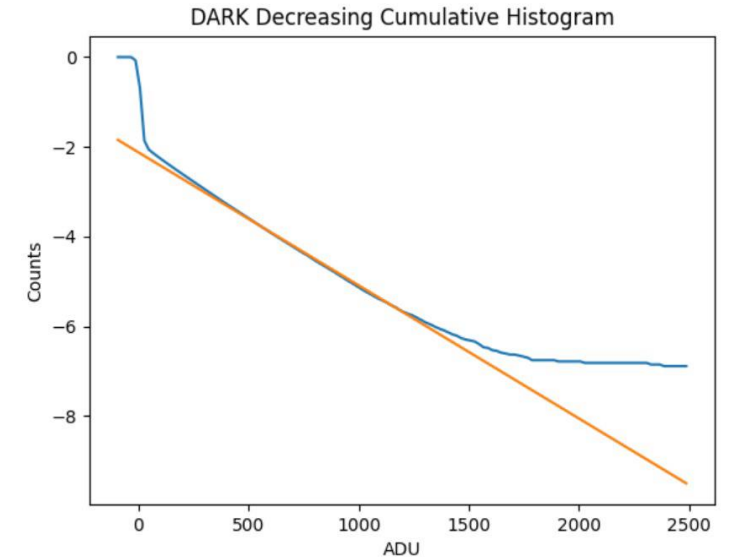
- Work ongoing on the noise model of the detector
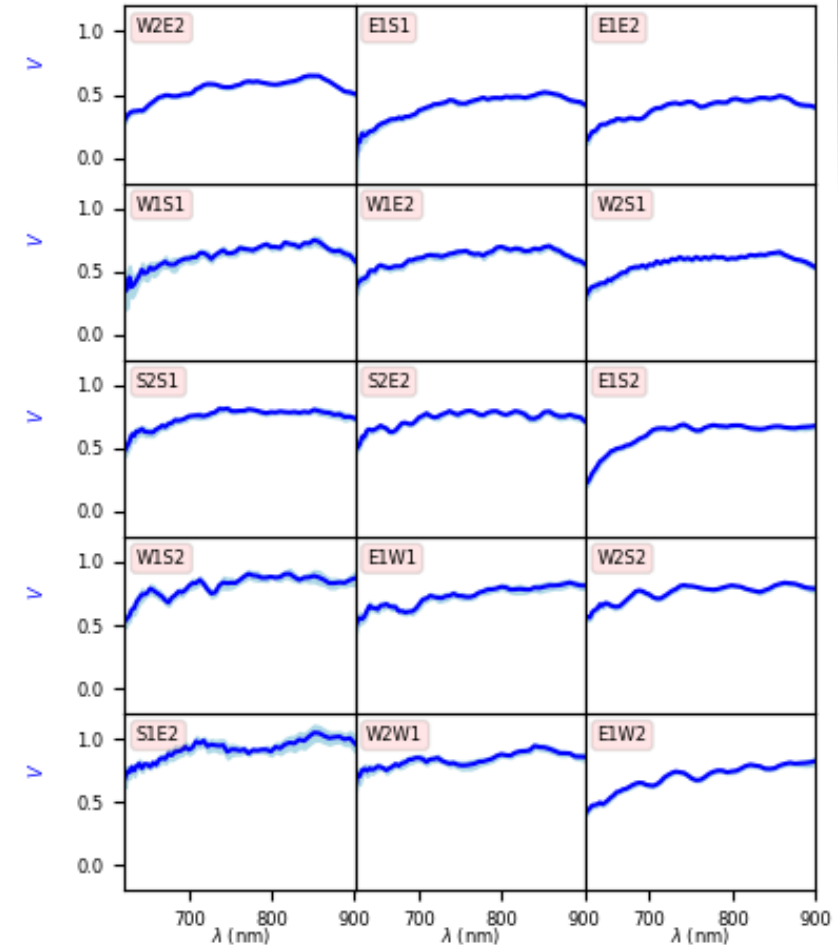
STS-VIS Feb 16, 2024

SPICA

STS measurements and ANDOR evaluation

Color: Halogen lamp at different brightness
Black: SPICA noise model (*)
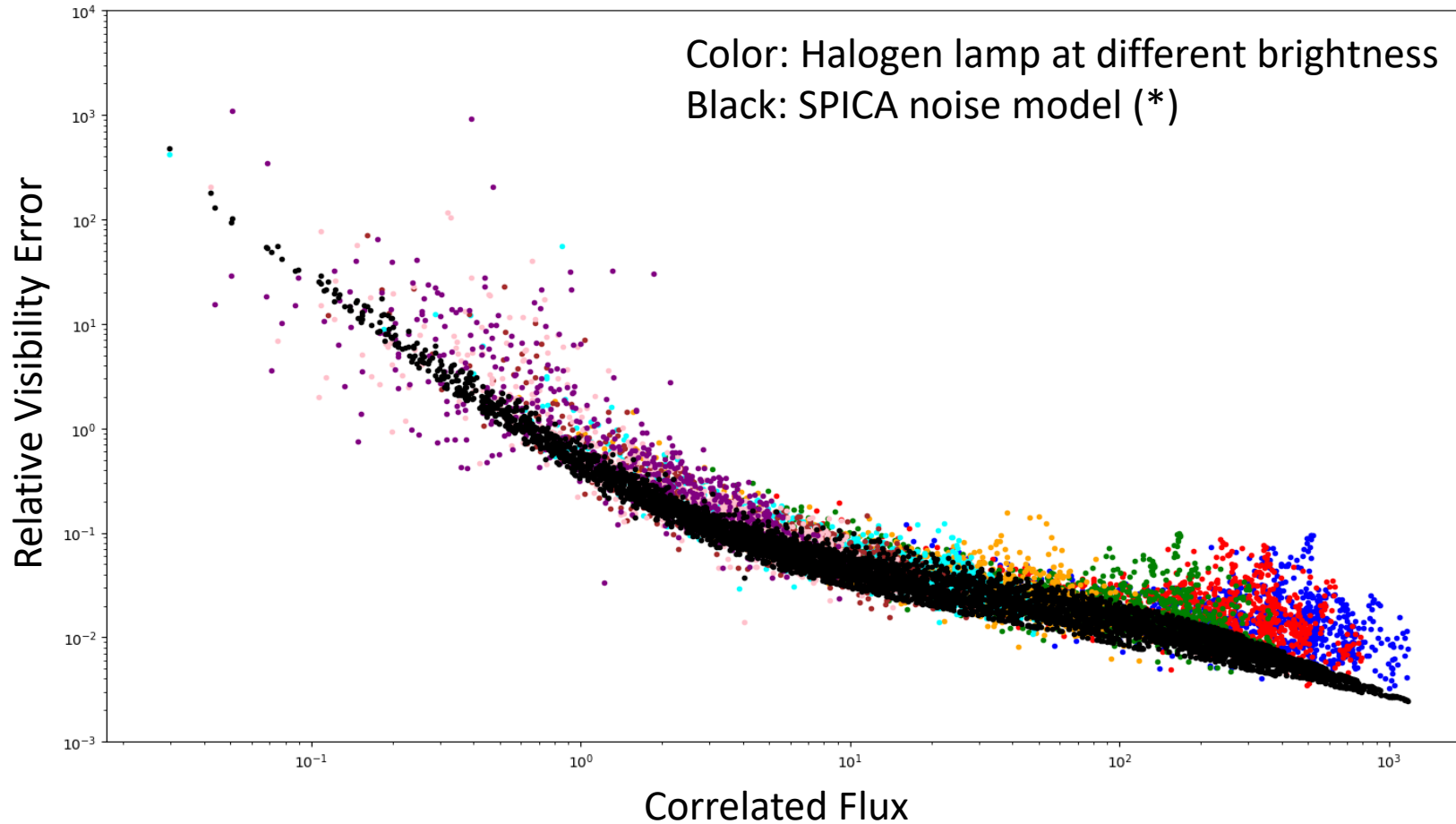
Science detector under investigation with ANDOR as the amplification gain is not coherent with was is expected (140 instead of 1000)

SPICA-FT achievements

- Real Time processing of 6T H-band data for Group Delay and Phase Delay tracking

- Good performance but not enough time in 2023 to use the PD tracking routinely

- Works in progress
  - Robust switch between TRACK and RELOCK (change of estimator of variance to be automatized)
  - Use of reference vectors (for the closure phase) for resolved stars and for the ABCD IO chip

- Use of the IO chip:
  - new OAP + MIRCx alignment ➔ more flux in MIRCx AiO (~1.3-1.5x)
  - First estimation for SPICA-FT IO chip ~1.3x MIRCx in term of transmission (not yet on sky)

SPICA

SPICA-FT achievements
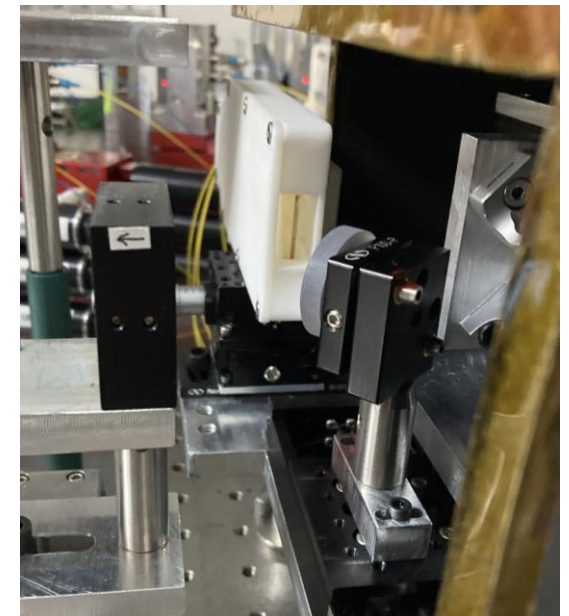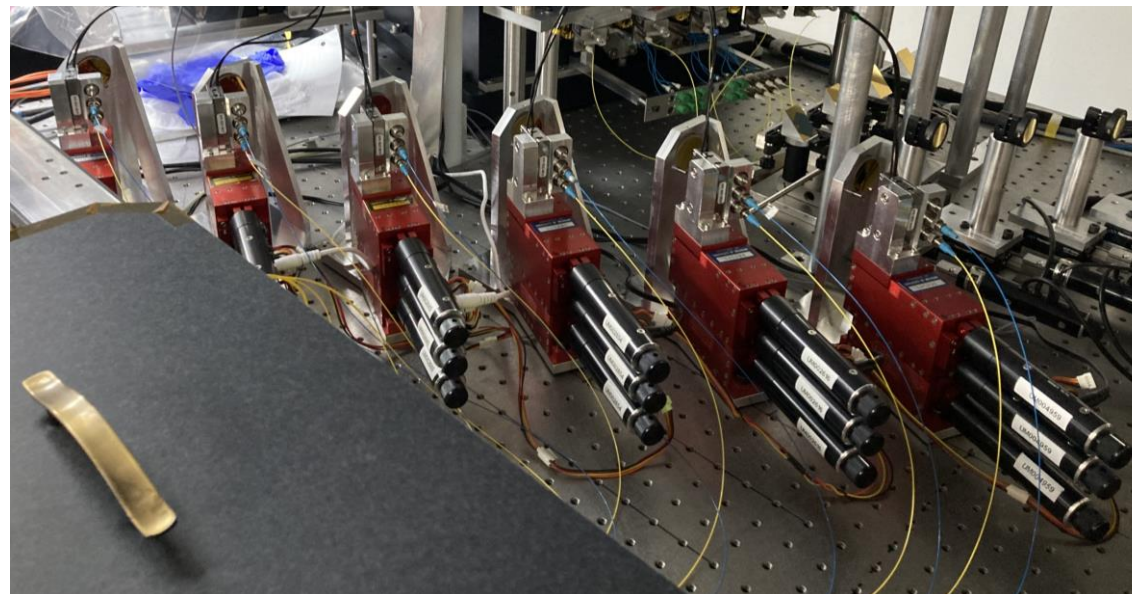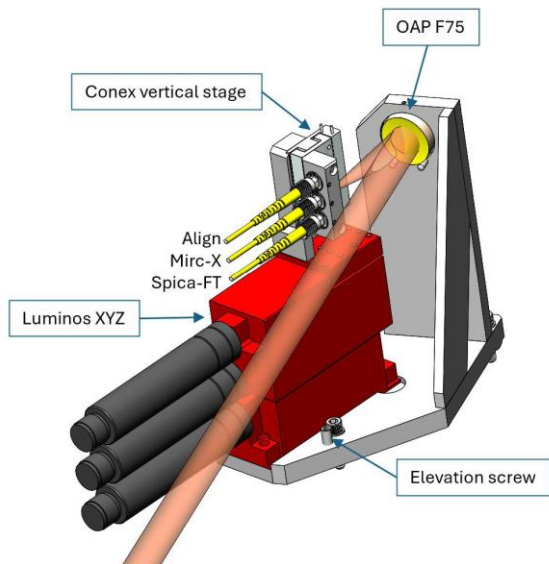
HD35411, mH ~4, unresolved, rms ~100nm, 300Hz

SPICA
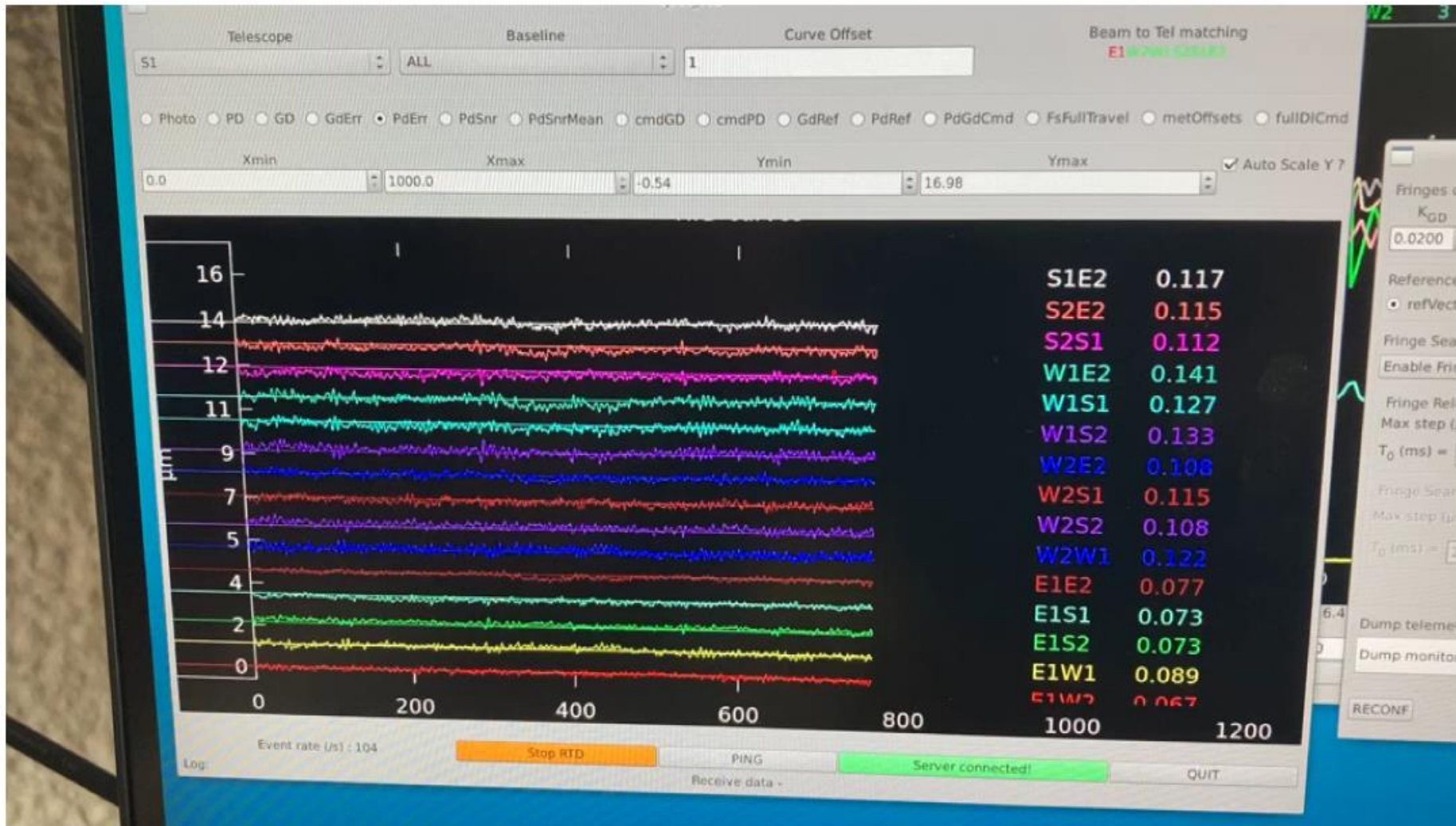
ISSP Survey progresses

ISSP progress: 124 Science OB in 2023B (19 effective nights), 42 with MIRCx&MYSTIC also recorded
Processing done at ~80% but very poor results at the end.

End of night sequence
   Data are copied at Mt Wilson, processed (dark, spectral calibration, then raw visibility); Filter is applied on flux, and filter on SPICA-FT data will soon be implemented.
   L0 (headers) and L1 data (uncalibrated visibilities) are copied in Nice and indexed in OiDB and ObsPortal
   Plots are generated for quality check

Calibration
   Python tool developed by Philippe Bério and adapted also for MIRCx and MYSTIC data
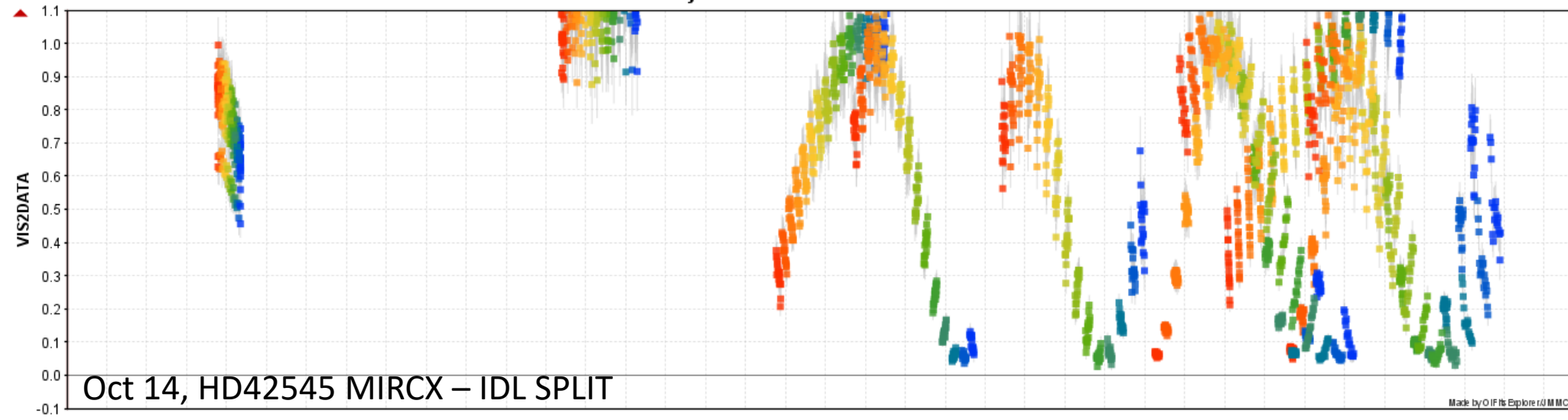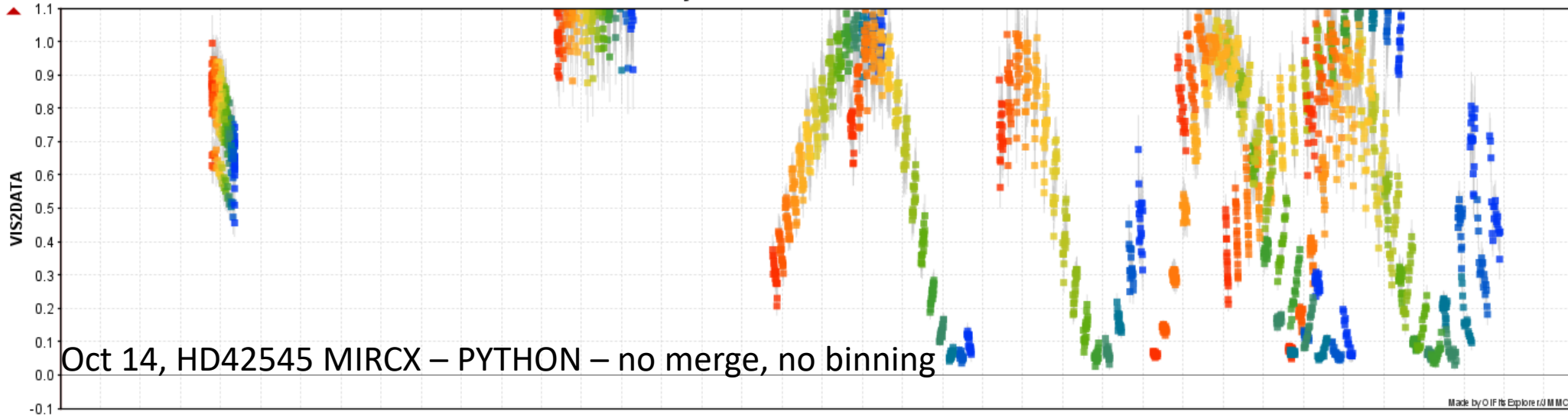   Due to the difficulties encountered with the data, this step is not yet automated.

Processing of non-ISSP programs done also (PI Roettenbacher and Wysocki in 2023B)

SPICA

CHARA - MIRCX [1.5019 μm - 1.7243 μm] - S1-S2-E2-W1-W2
Day: 2023-10-14 - Source: HD42545

Oct 14, HD42545 MIRCX – PYTHON – no merge, no binning

Oct 14, HD42545 MIRCX – IDL SPLIT

Conclusions

SPICA-VIS: good progresses in 2023 but difficulties for Science

AOs, vibrations ➜ urgent fix needed + monitoring of performance

More work to be done in 2024 for SPICA-FT (➜ part of the activity in the engineering nights)

First non-ISSP programs in 2023B; 12 nights in 2024A but shared risk and probably still poor performance unfortunately

See Juraj's, Nayeem's and Mathieu's presentations for first 'results'. No science paper up to now.

SPICA