The installation and commisionning of

MATISSE

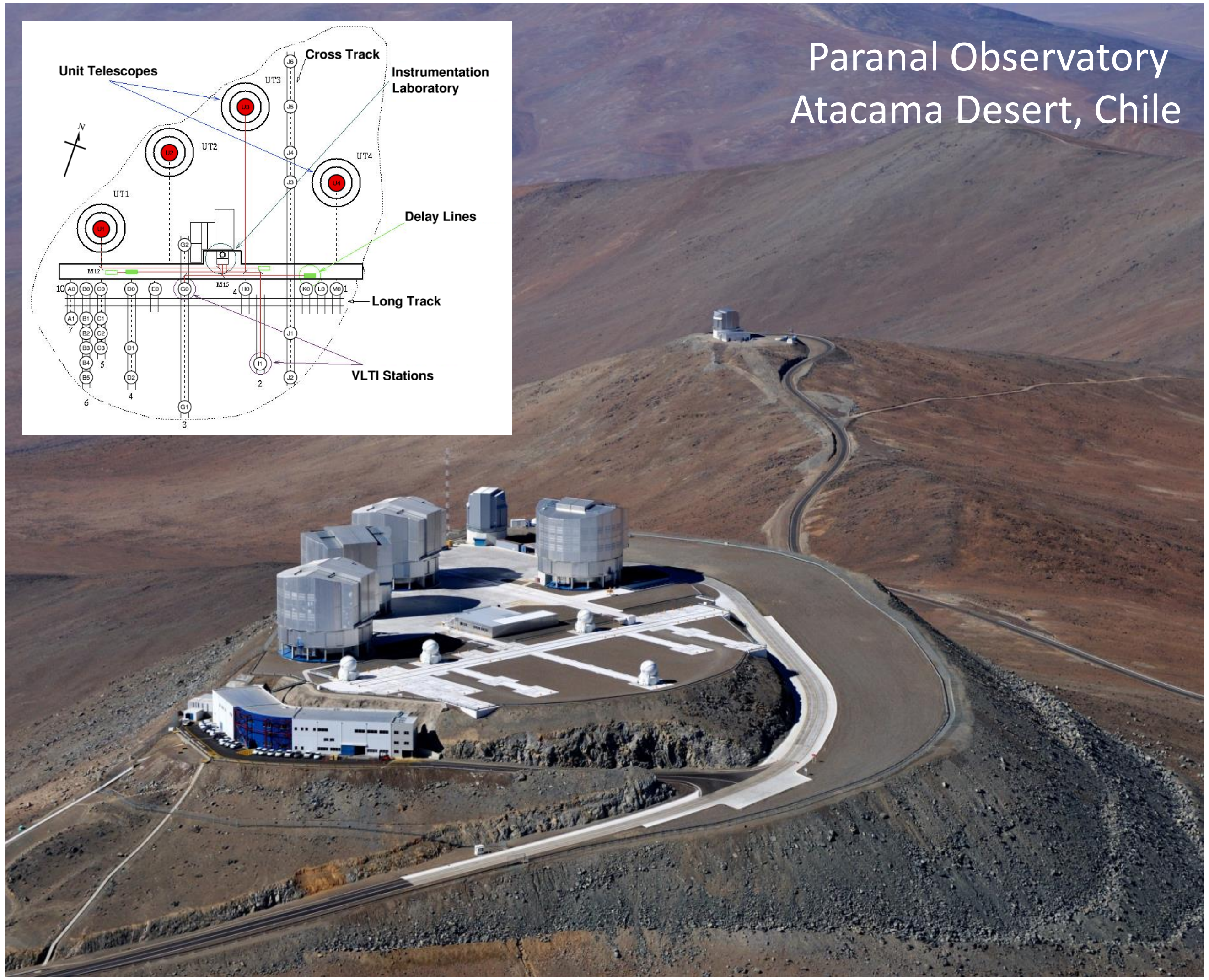
The new VLTI mid-infrared instrument

Anthony Meilland

And the MATISSE commissioning team

Bruno Lopez, Stephane Lagarde, Romain Petrov, Philippe Bério, Florentin Millour, Pierre Cruzalebes, Sylvie Robbes, Fatmé Allouche, Alexis Matter…

Current Status of VLTI



4 Unit Telescopes (8.2m)

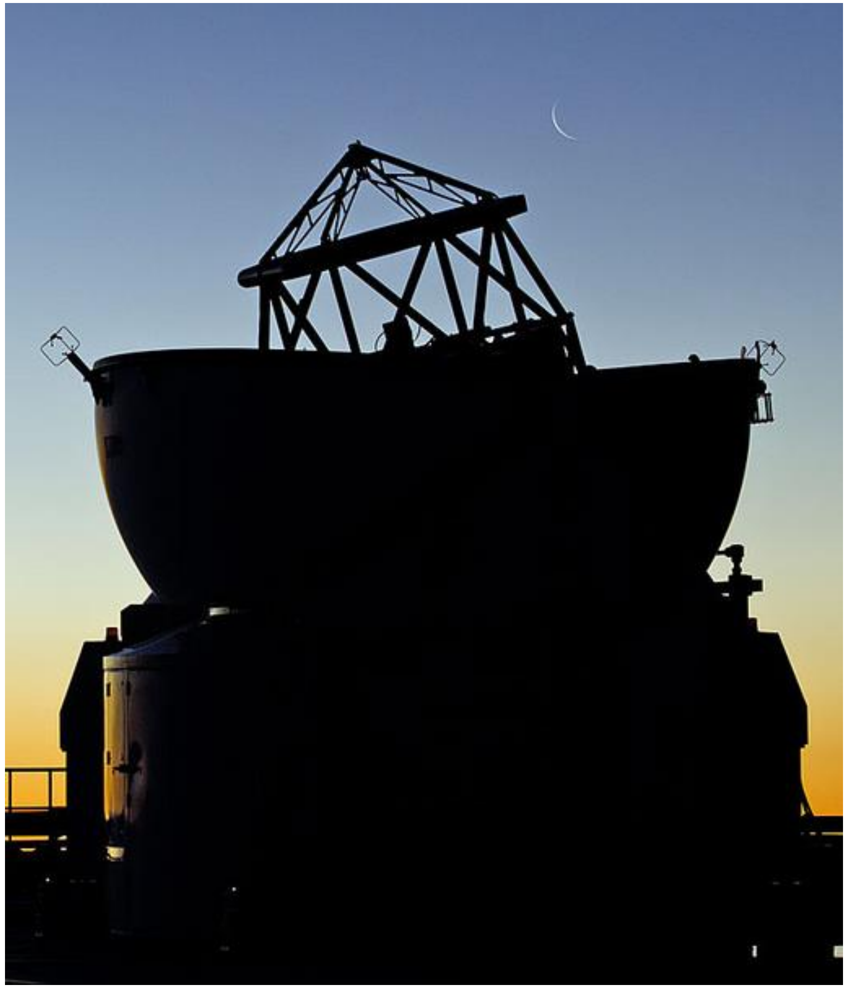
- Fixed : B = 46 – 130 m
- Equipped with 60 actuators AO (MACAO)
- Two wavefront sensors:
  - Visible : MACAO
  - Near-IR : CIAO (developed for GRAVITY)

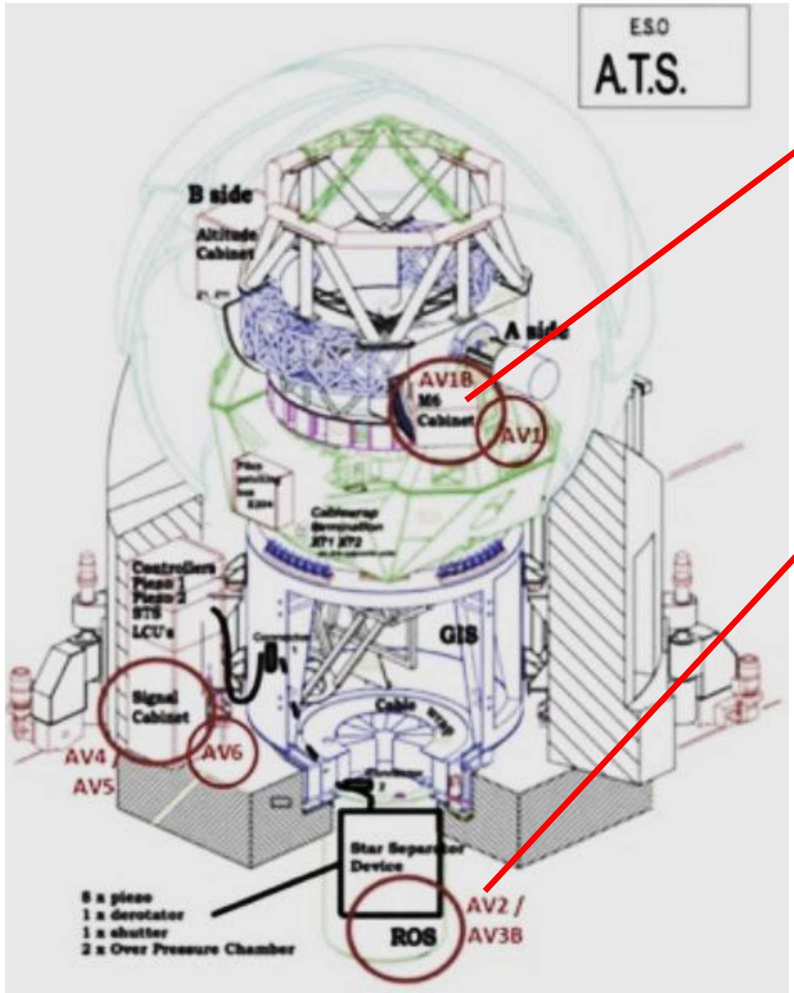
4 Auxiliary Telescopes (1.8m)

- Movable : B = 13 – 140 m
- Recently equipped with a AO (NAOMI)

Current Status of VLTI

NAOMI



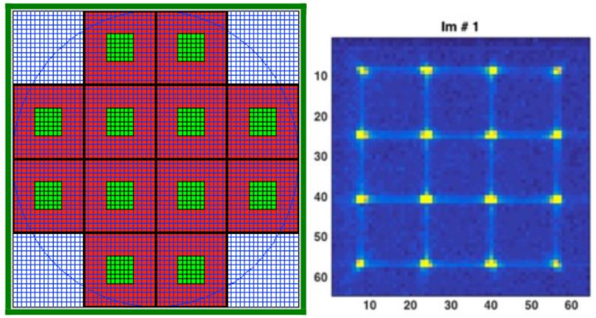


Deformable Mirror

ALPAO DM241

Wavefront Sensor

4x4 Shack–Hartmann



Installed in September 2018
Commissioned in fall 2018

Improve the limiting magnitude (1mag)
Faster object acquisition (<2min)

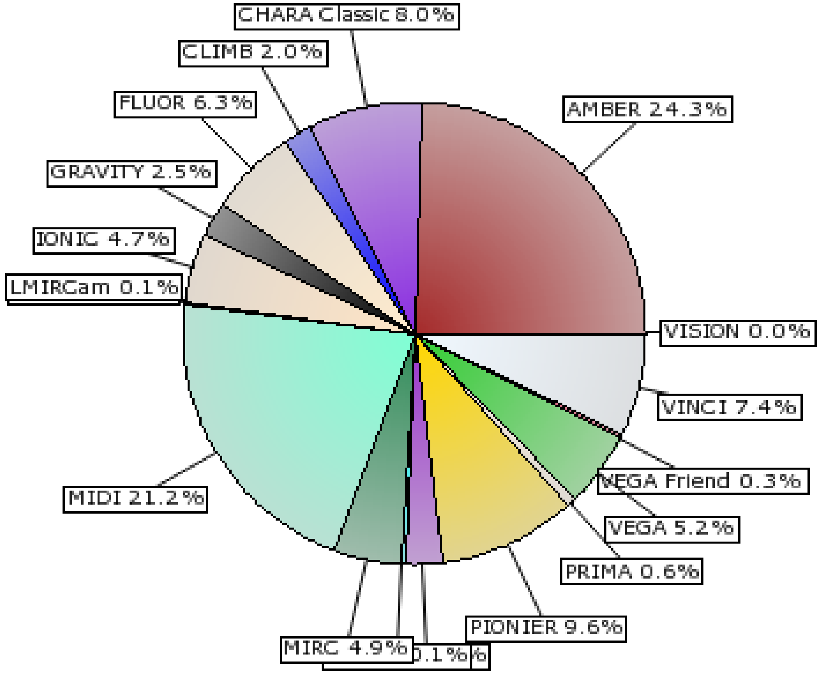
Current Status of VLTI

Installation of MATISSE warm-optics in the VLTI Lab (November 2017)

	nTel	Band	Spectral Res.	Available
MIDI	2	N	20-230	2001-2015
AMBER	3	(J)HK	30-12000	2003-2018
PIONIER	4	H	5-30	2010
GRAVITY	4	K	22-4000	2016
MATISSE	4	LMN	30-4000	2018

Current Status of VLTI

AMBER and MIDI deserve their retirement



Interferometric papers by instrument
(source : JMMC bibDb)

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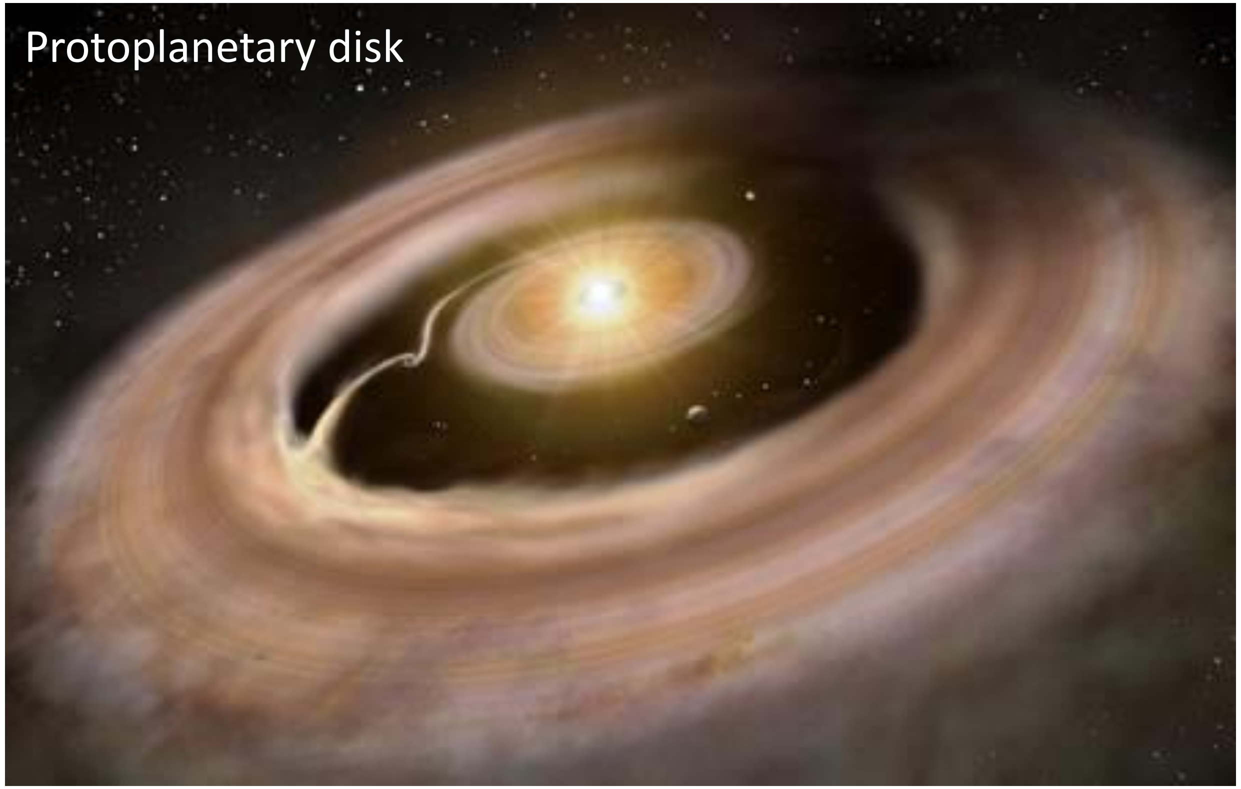
MATISSE	4	LMN	30-4000	2019

MATISSE : a lot more than MIDI successor !

Pierre Antonelli (Project Manager), Bruno Lopez (PI), and Philippe Berio (DRS) in the MATISSE integration room in Nice

MIDI	MATISSE	
2 Telescopes	4 Telescopes	
Co-axial	Multi-axial	
N band	L&M bands	N band
8-13μm	3-5μm	8-13μm
R = 30, 230	R = 34, 506, 950 (4000)	R = 30, 220
Raytheon IBC	HAWAI-2RG	AQUARIUS
320x240	2048x2048	1024x1024

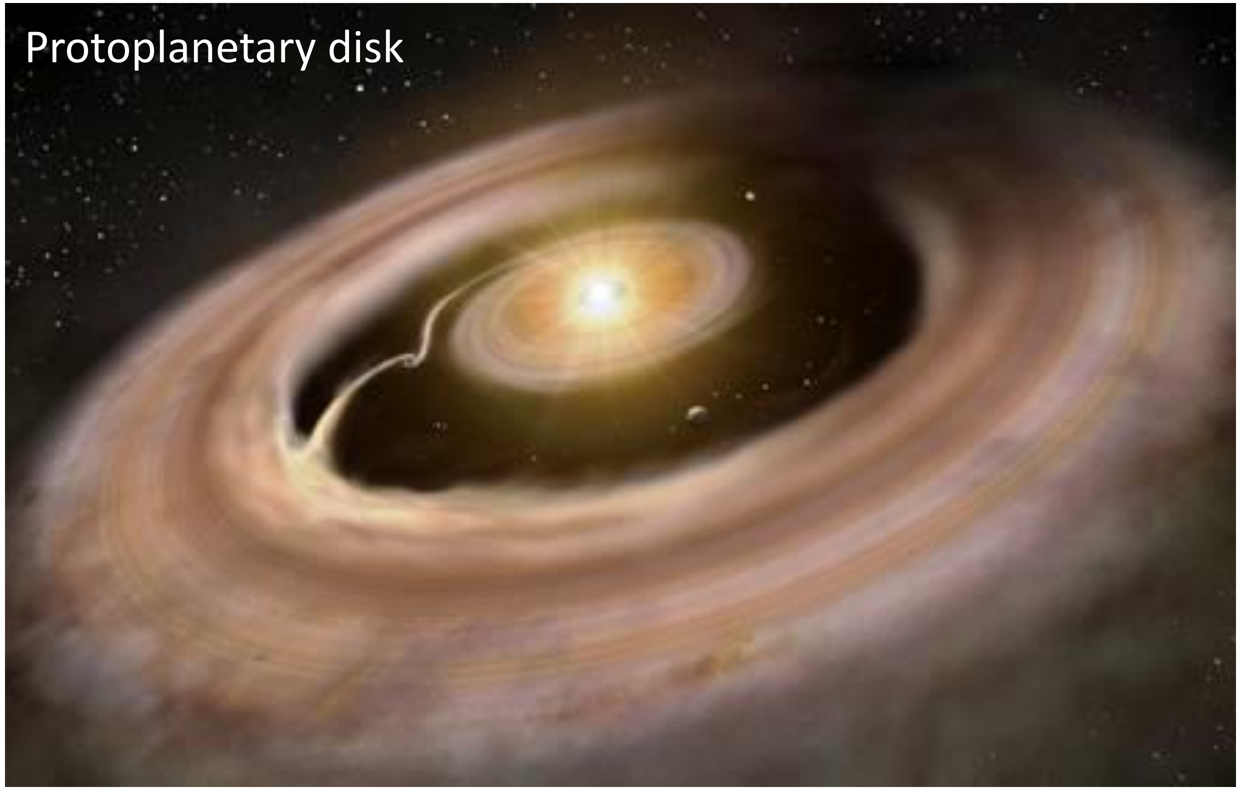
The science cases of MATISSE

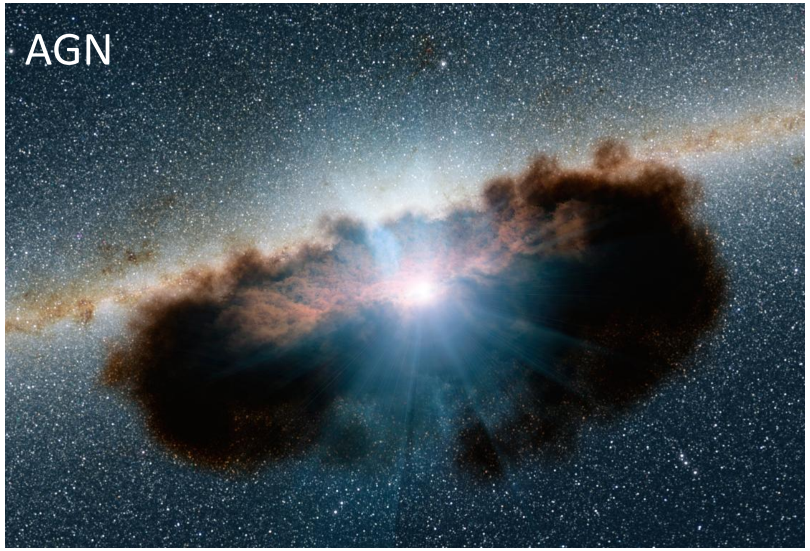


Feature	Wavelength (μm)
L- and *M*-bands (~ 2.8–5.0 μm)	
H_2O (ice)	3.14
H_2O (gas)	2.8–4.0
H lines (Br-α, Pf-β)	4.05, 4.65
PAHs	3.3, 3.4
Nano-diamonds	3.52
CO fundamental transitions	4.6–4.78
CO (ice)	4.6–4.7
N-band (~ 8.0–13.0 μm)	
Amorphous silicates	9.8
Crystalline silicates (olivines and pyroxenes)	9.7, 10.6, 11.3, 11.6
PAHs	8.6, 11.4, 12.2, 12.8
Fine structure lines (e.g., [S IV], [Ne III], [Ne II])	10.5, 10.9, 12.8

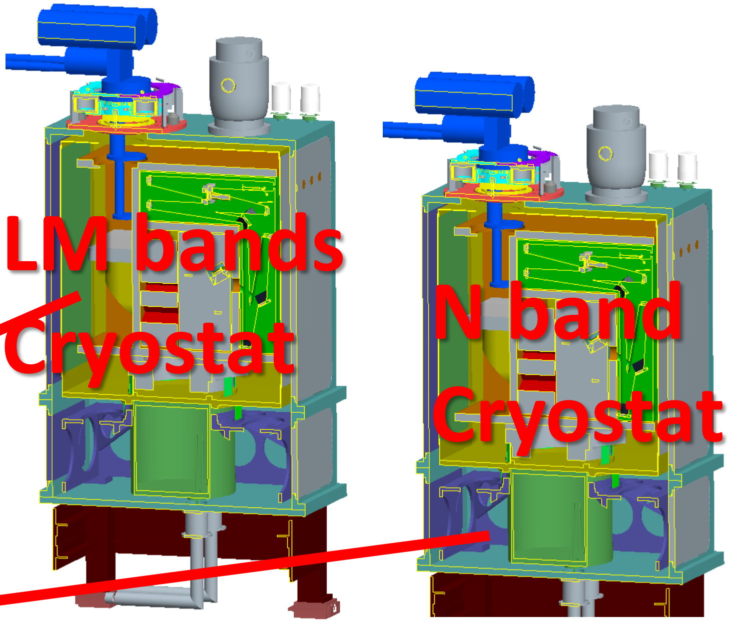
- Study temperature and density profile in the disk (in conitnuum L,M, and N bands)
- Detect gaps and other structures in the disk
- Locate chemical elements in the disk such as water, ice, CO,…

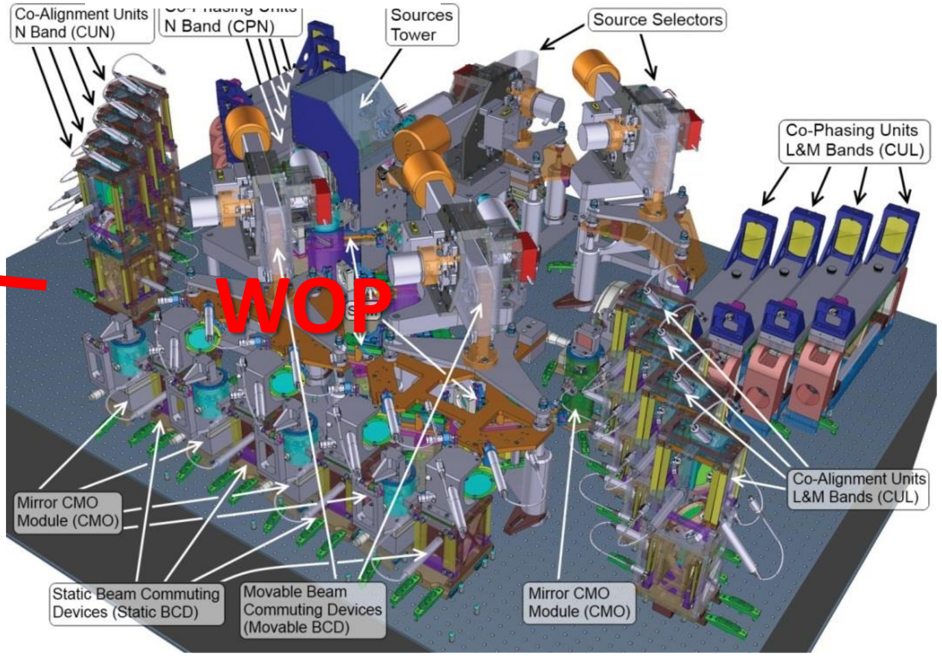
The science cases of MATISSE



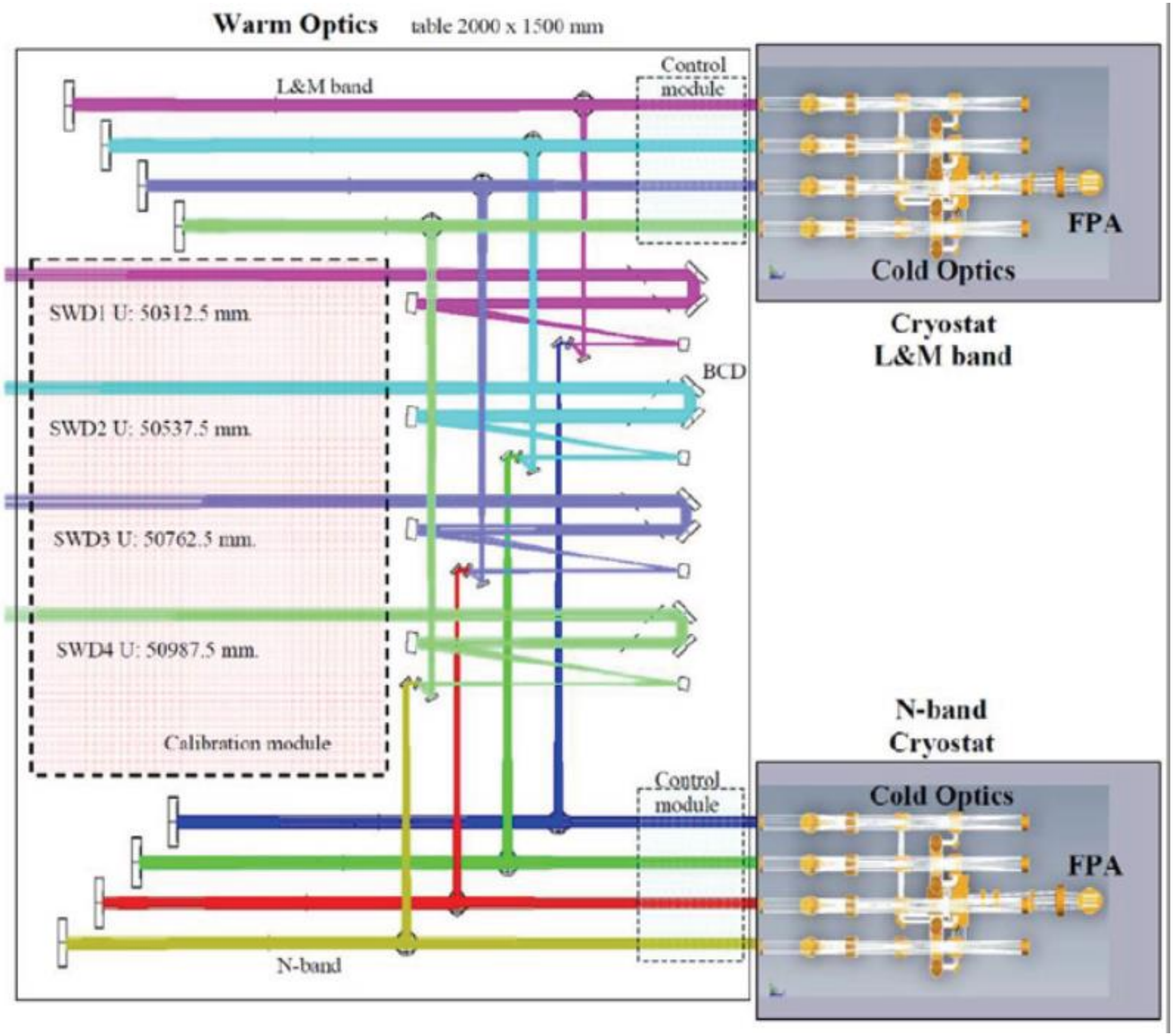


MATISSE WOP & Cryostats

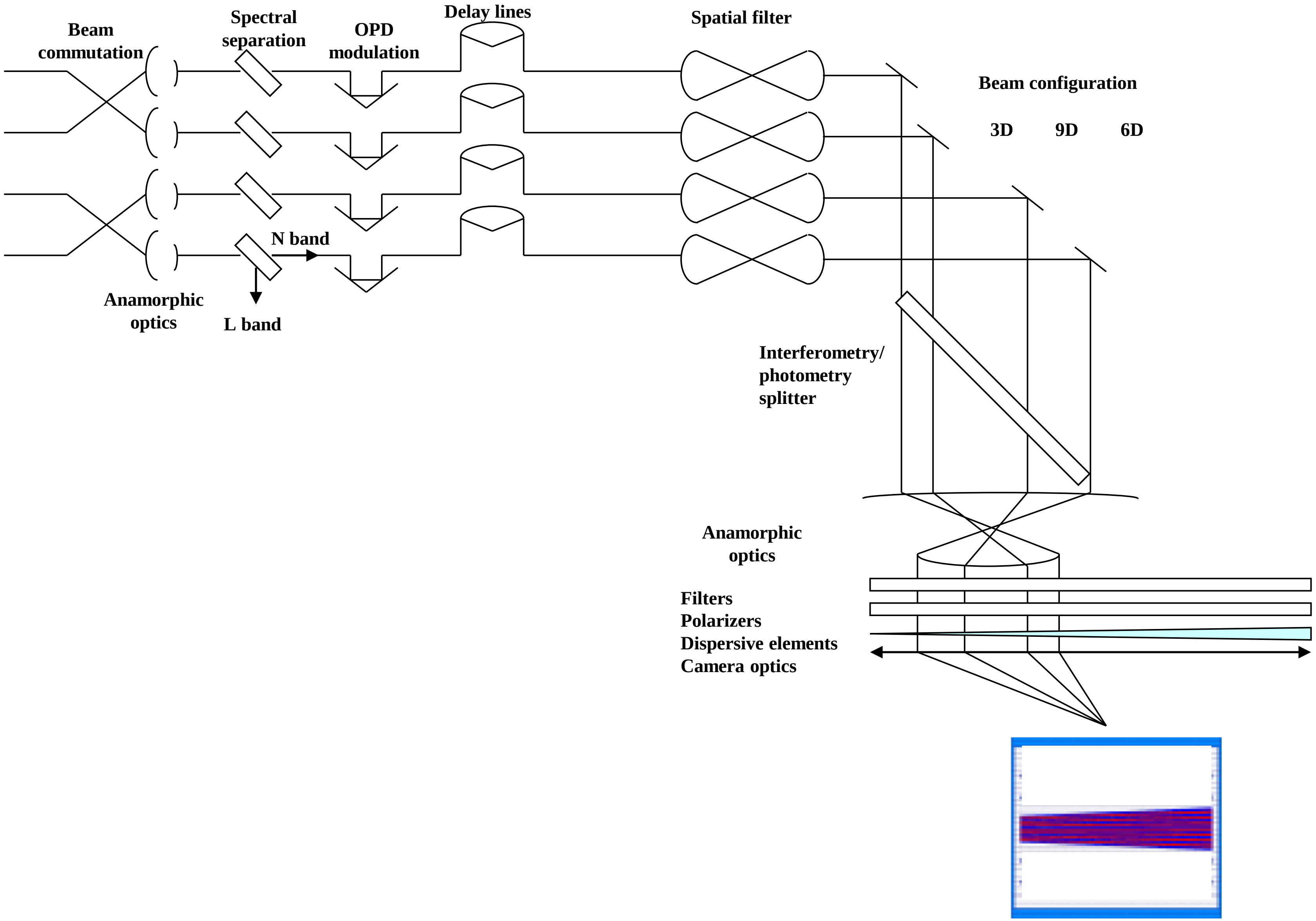




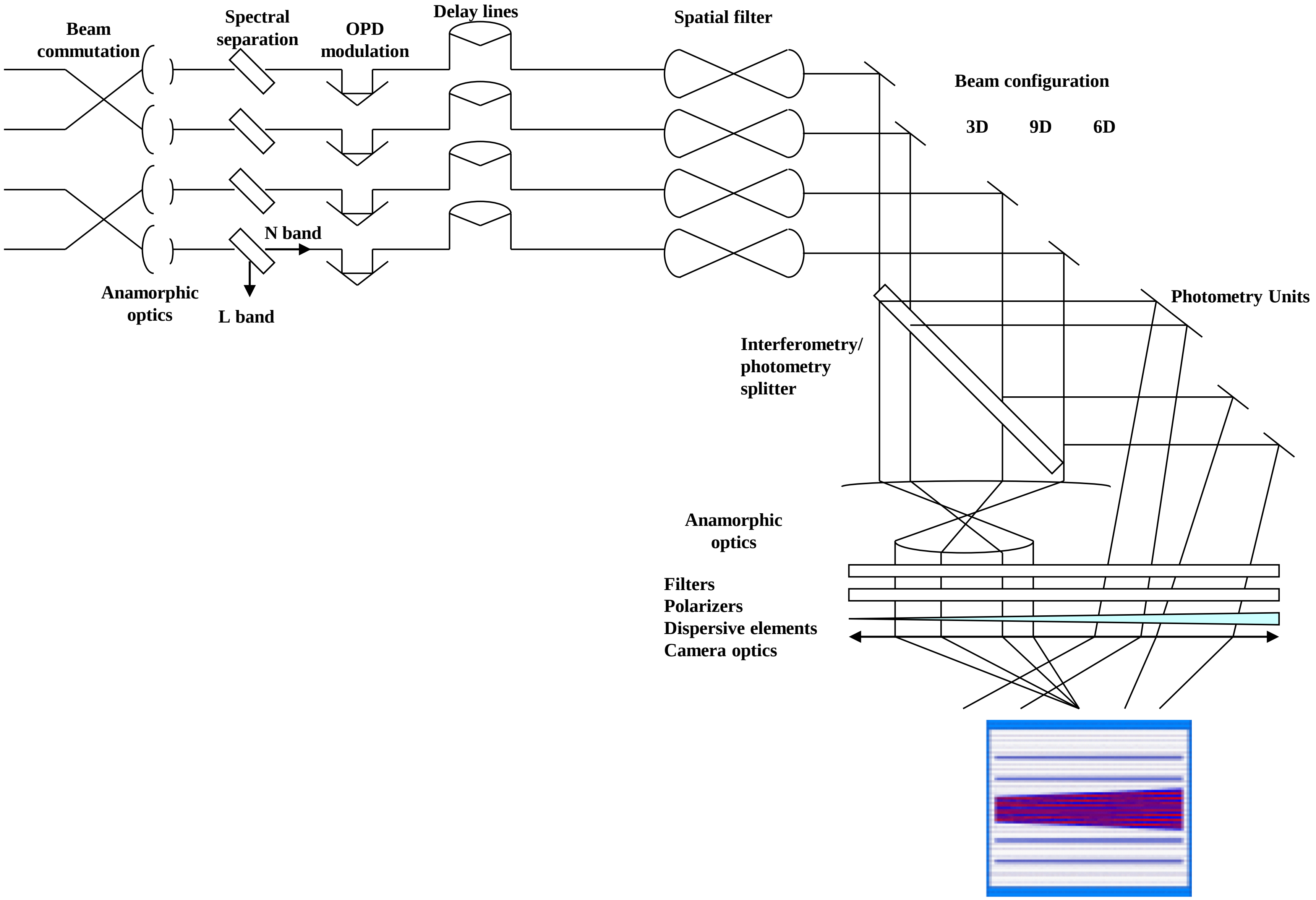
MATISSE optical-path



Principle of MATISSE

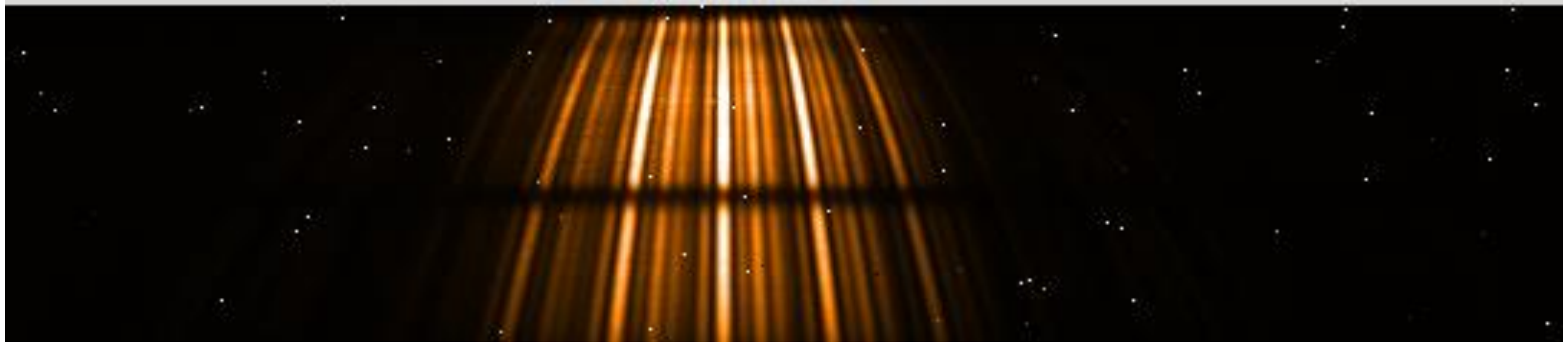


Principle of MATISSE

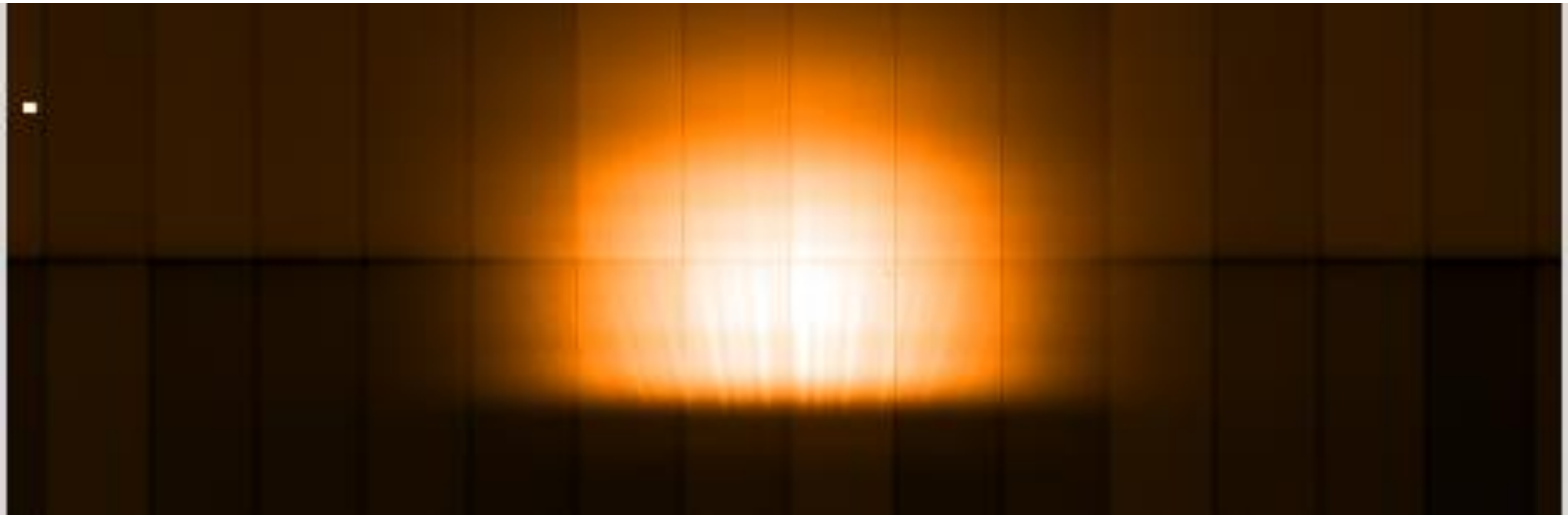


MATISSE Low Resolution Fringes

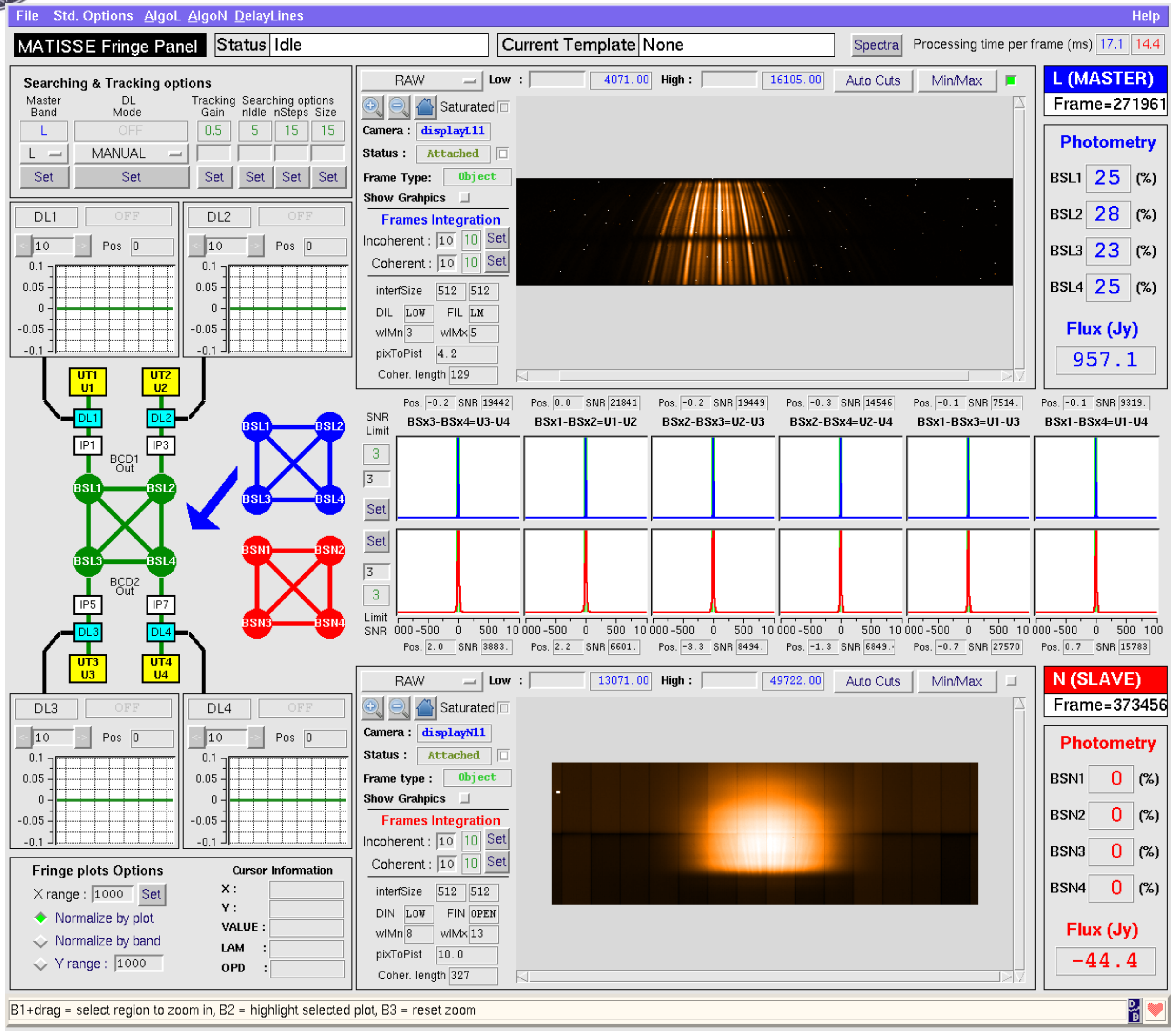
L&M bands

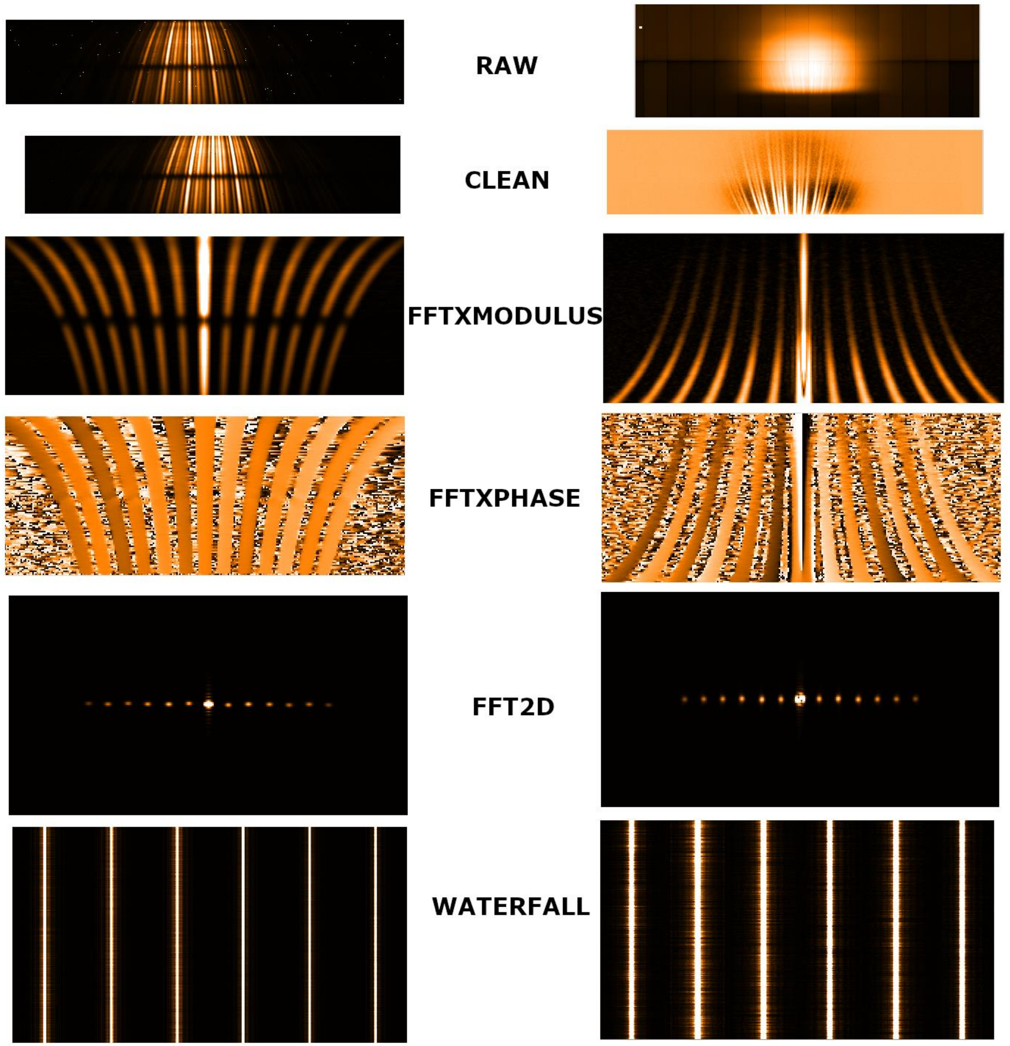


N band



MATISSE Fringe coherencing software



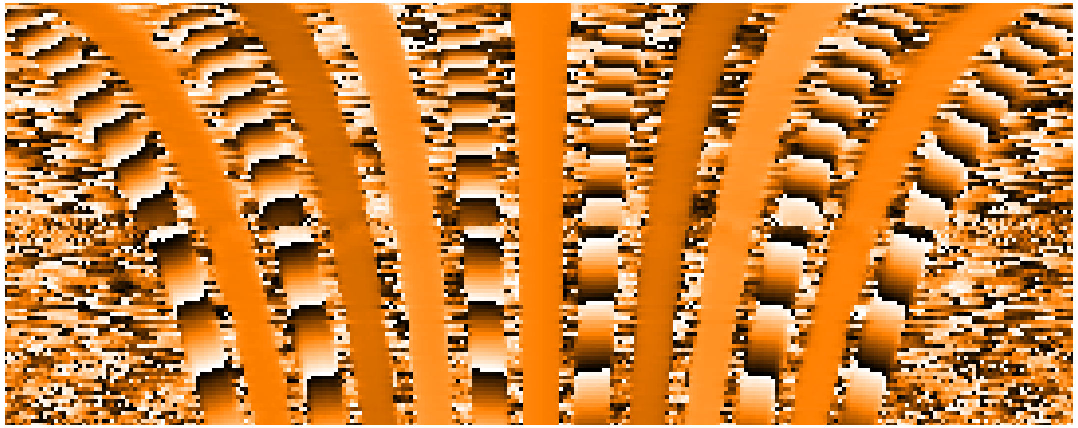


MATISSE Fringe coherencing software

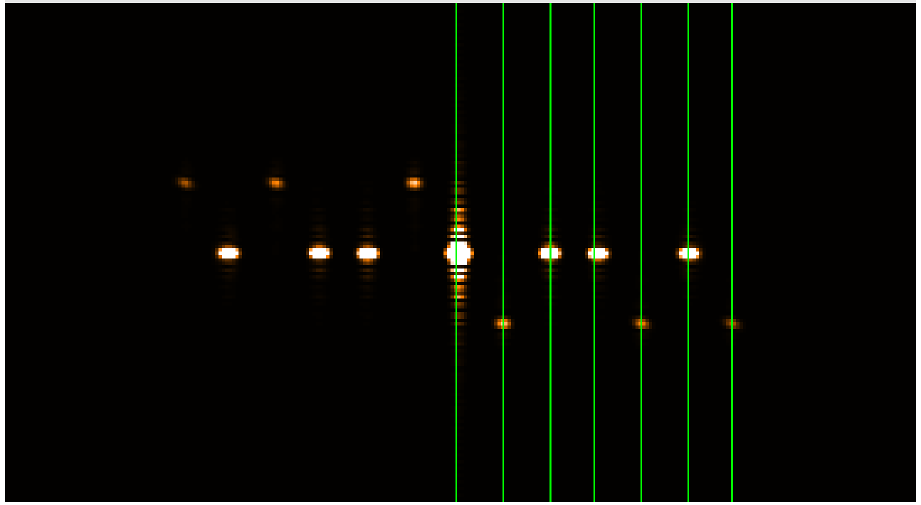
Non-zero-OPD Fringes

Clean Fringes

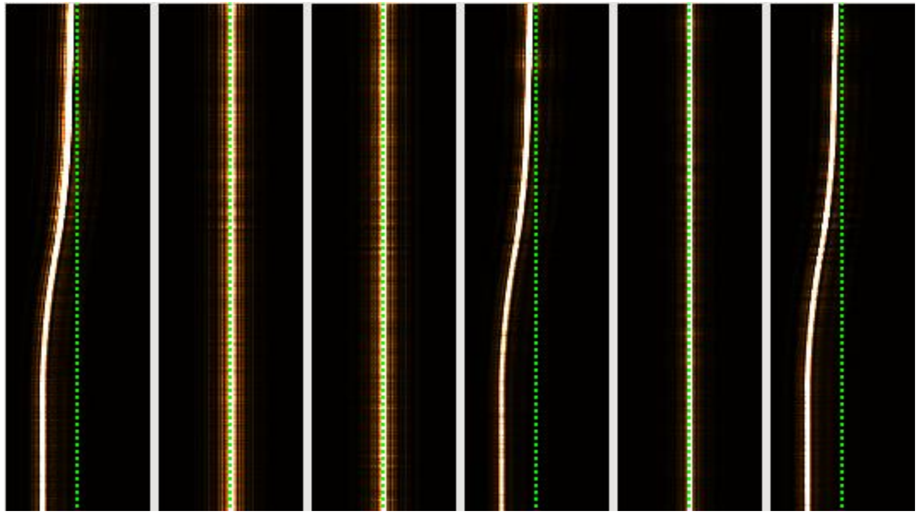
FFTX phase



FFT2D modulus



Fringe peaks waterfall



Integration in Paranal (October-December 2017)

“First Light” (February 18, 2018)

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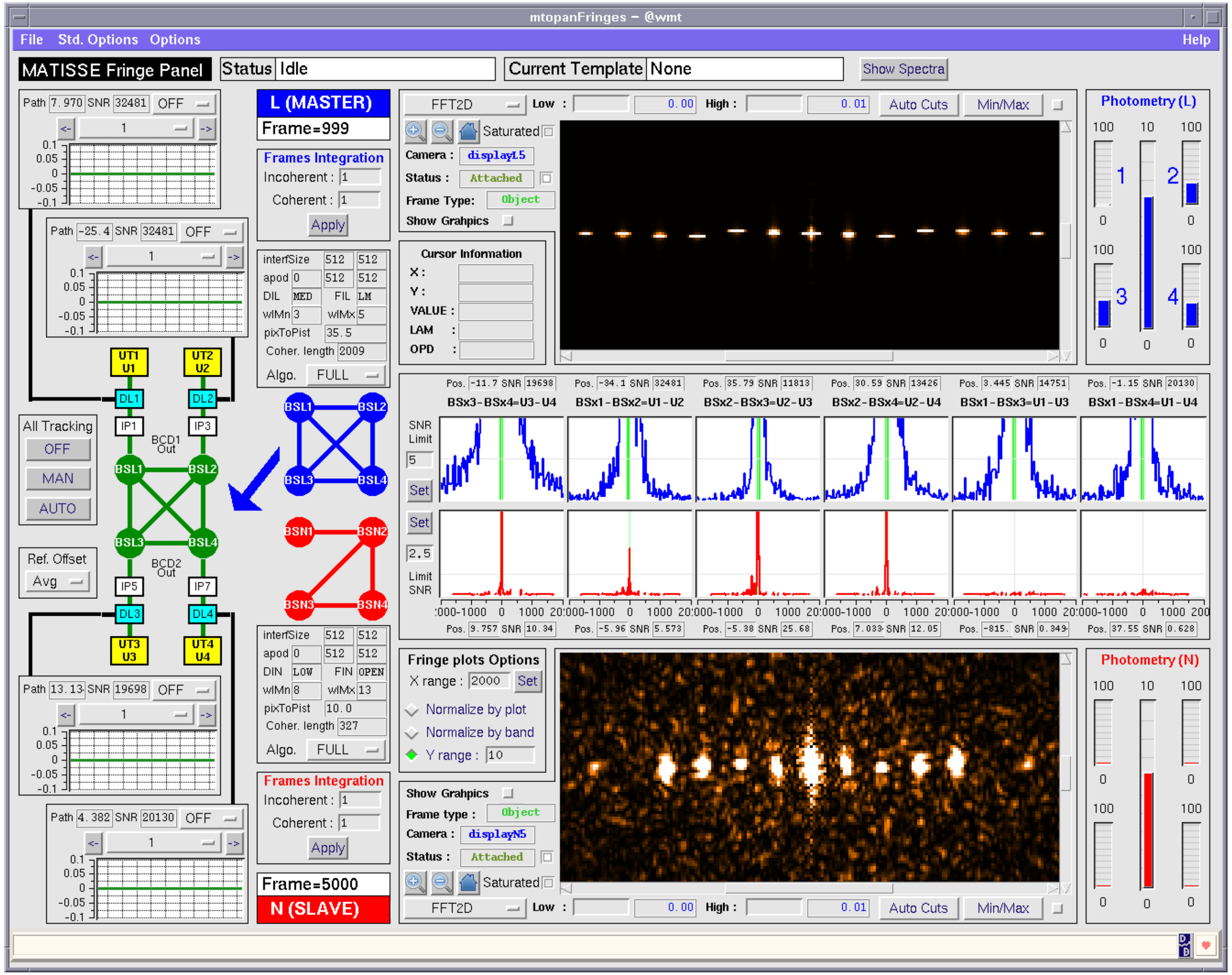
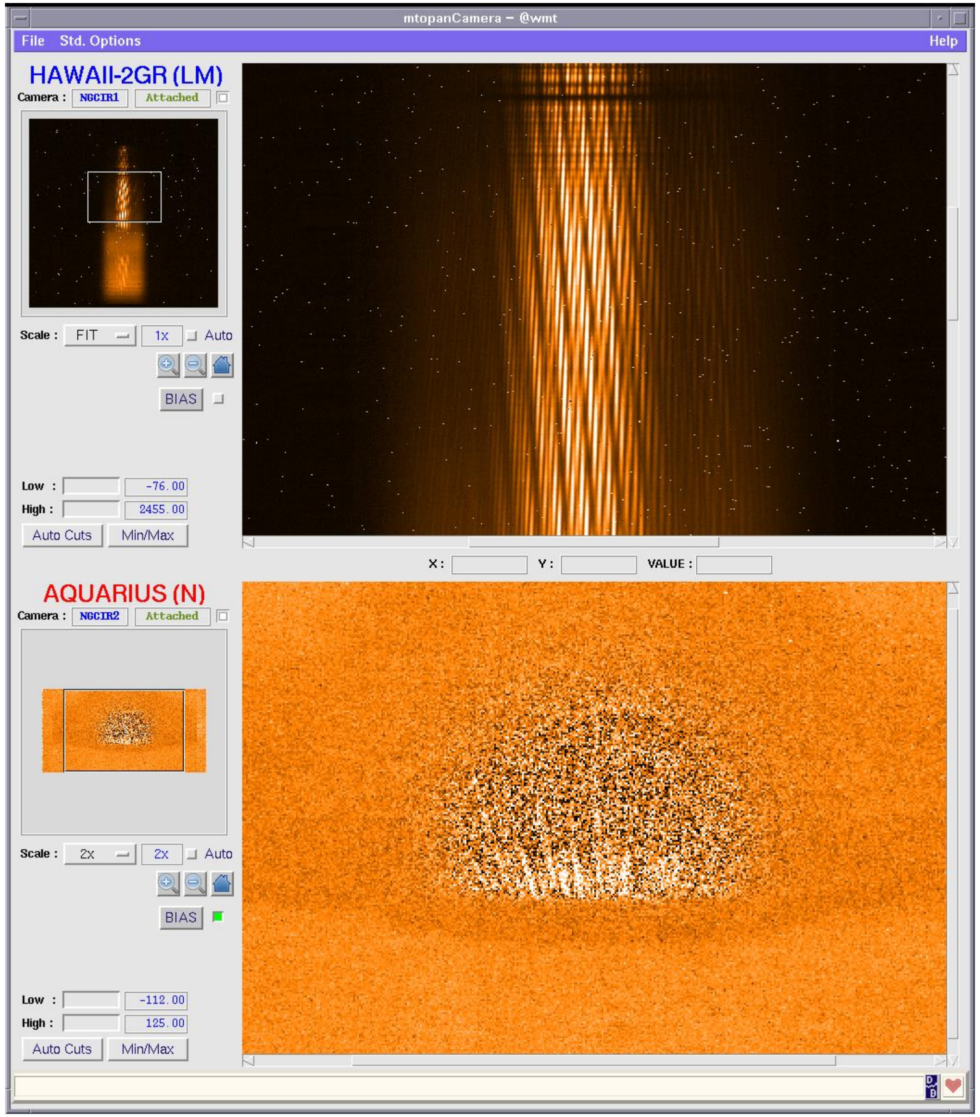
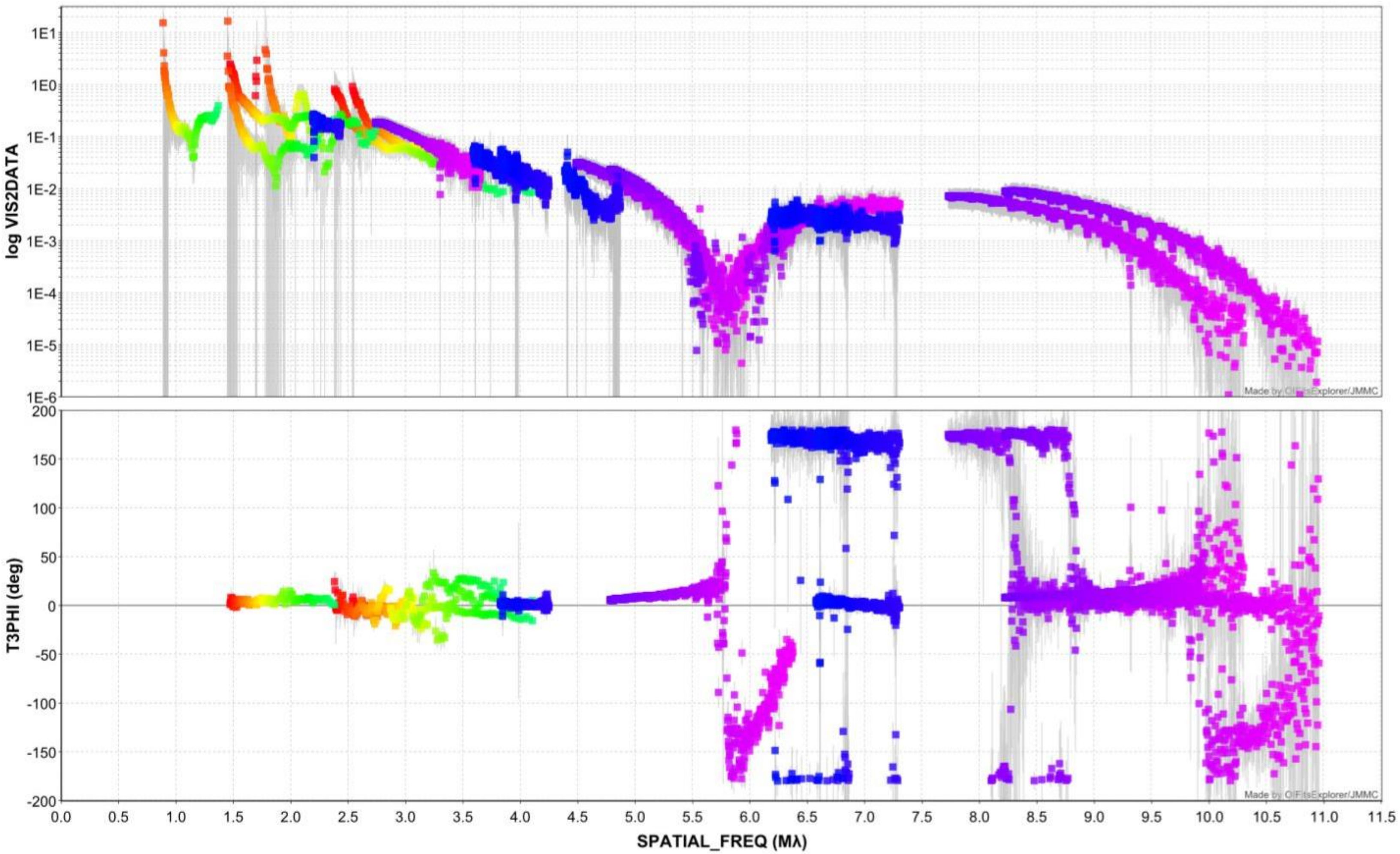




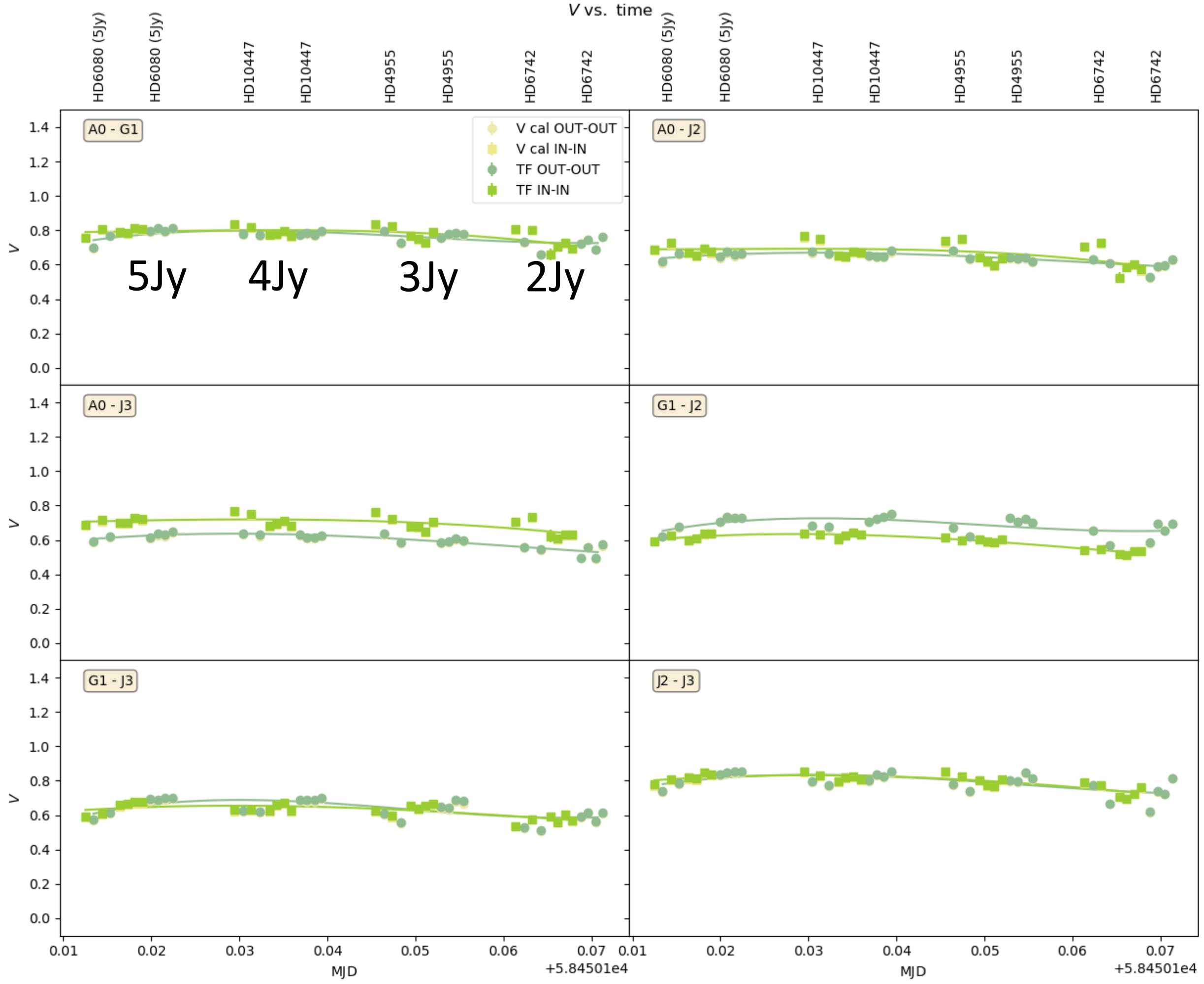
"First Light" (February 18, 2018)

Betelgeuse

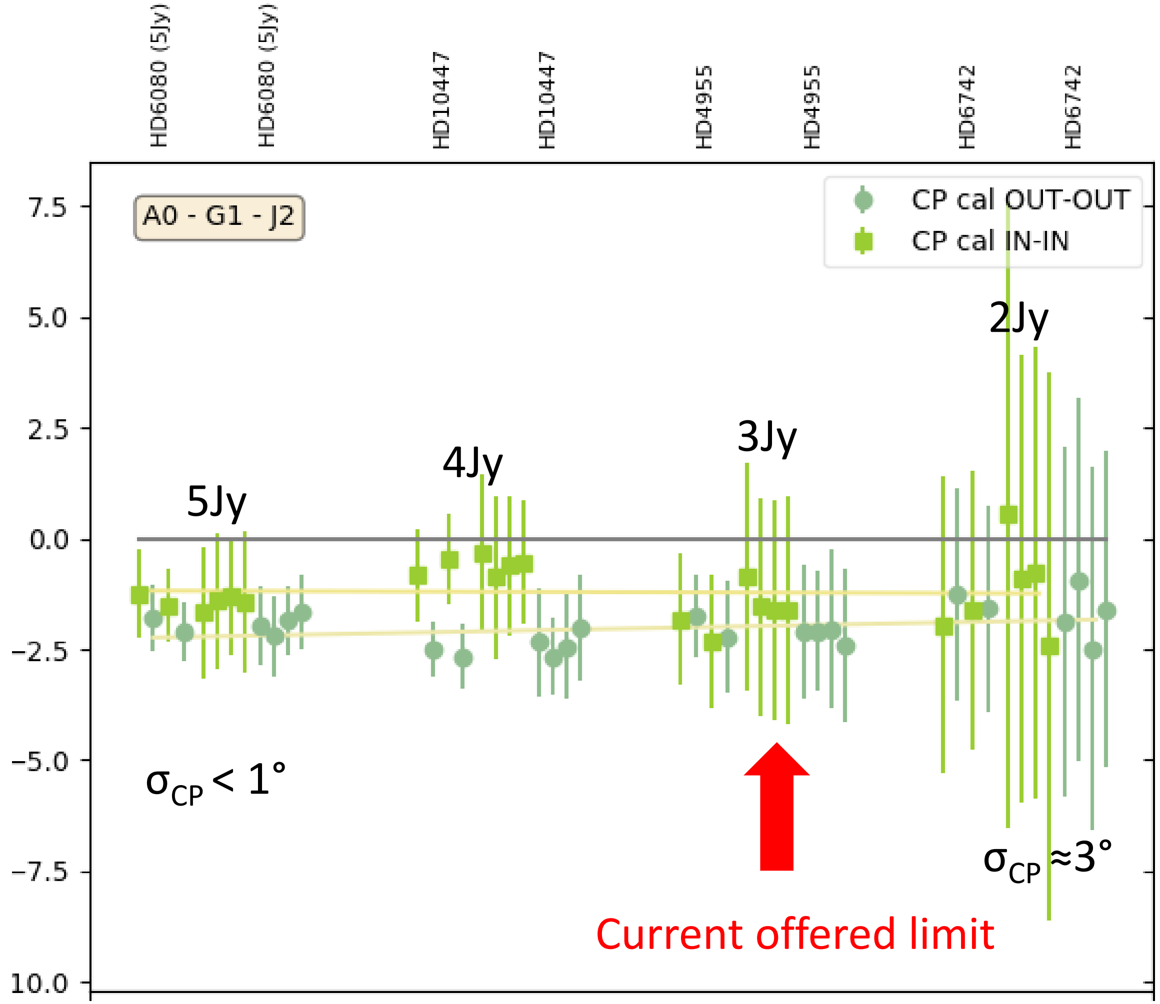


3 µm (L)
5 µm (M)
8 µm (N-)
13 µm (N+)

MATISSE Commissioning

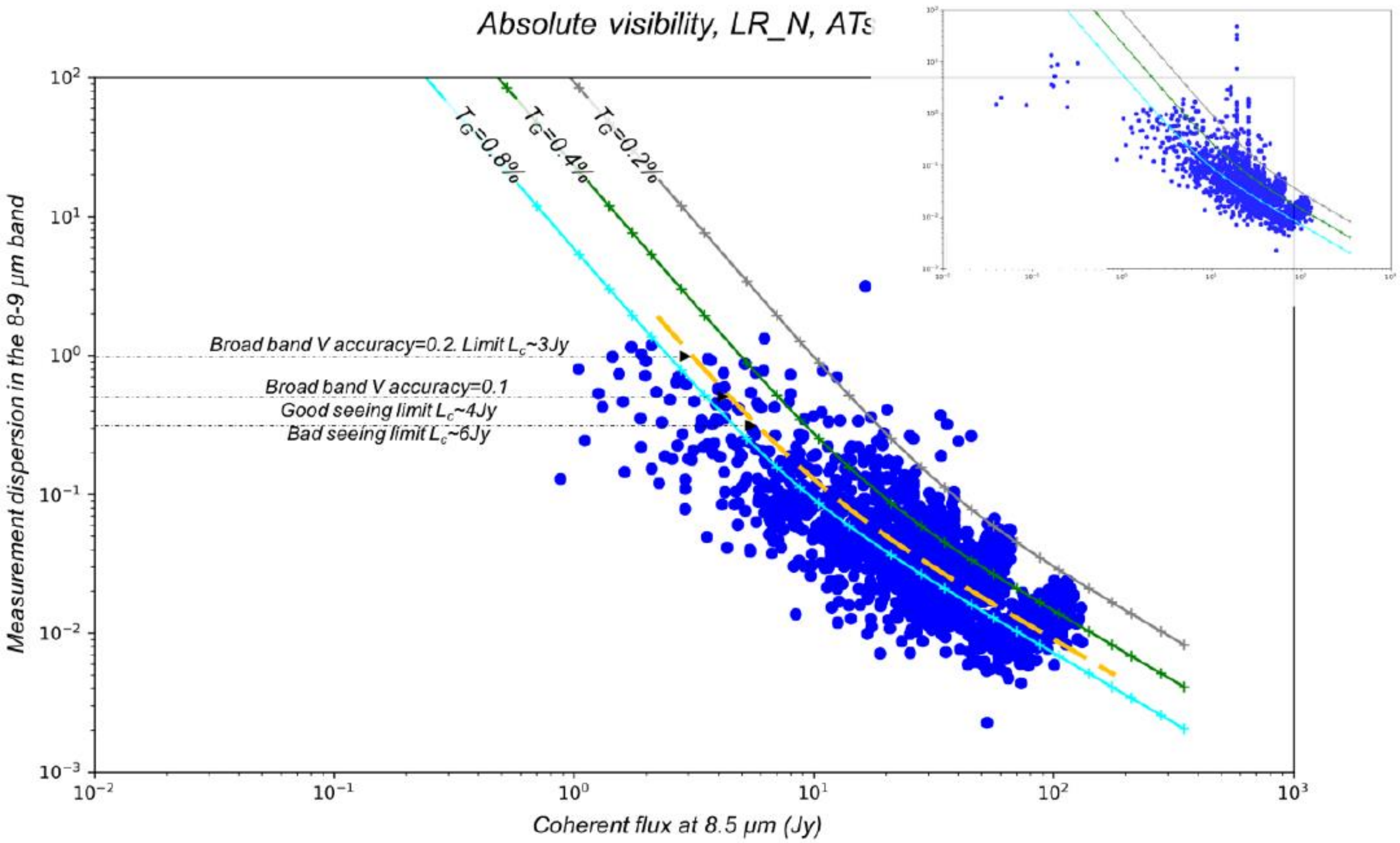


L-band visibilty on ATs



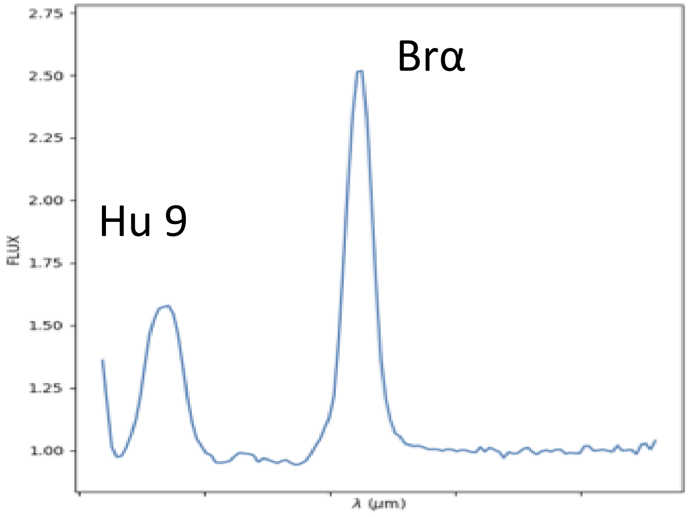
L-band Closure phase on ATs

MATISSE performance

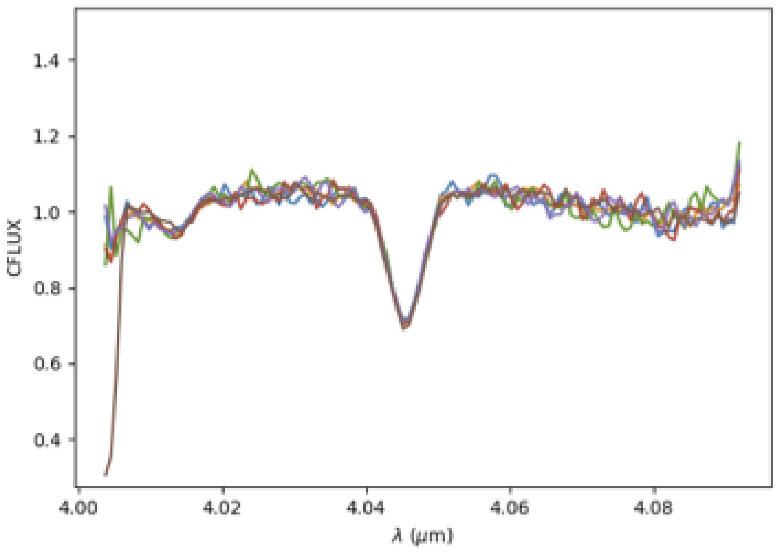


Observation in L-Band High Resolution (R=950)

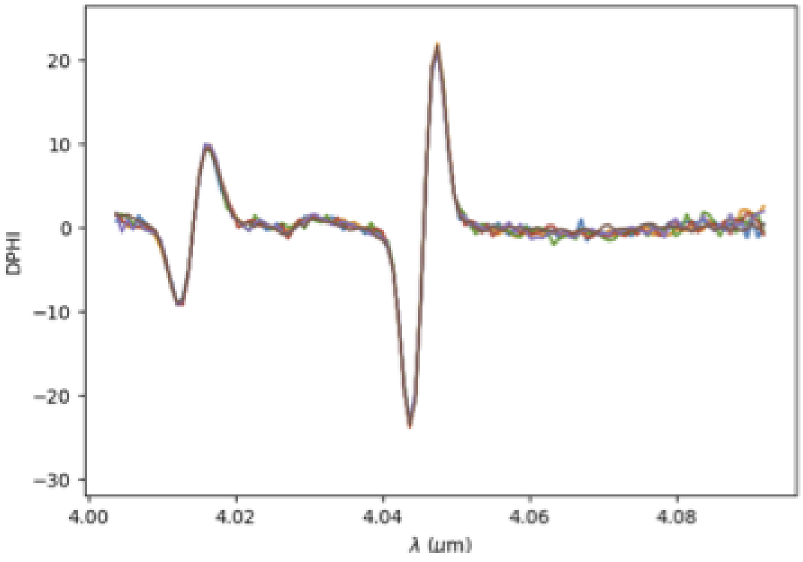
Example on an emission line star



Brα Line Profile (+ Hu 9)



Visibility



Differential Phase

Current Spectral range in HR mode limited by detector read time
DIT=111ms ⇔ 0.1nm

Observation in L-Band High Resolution (R=950)

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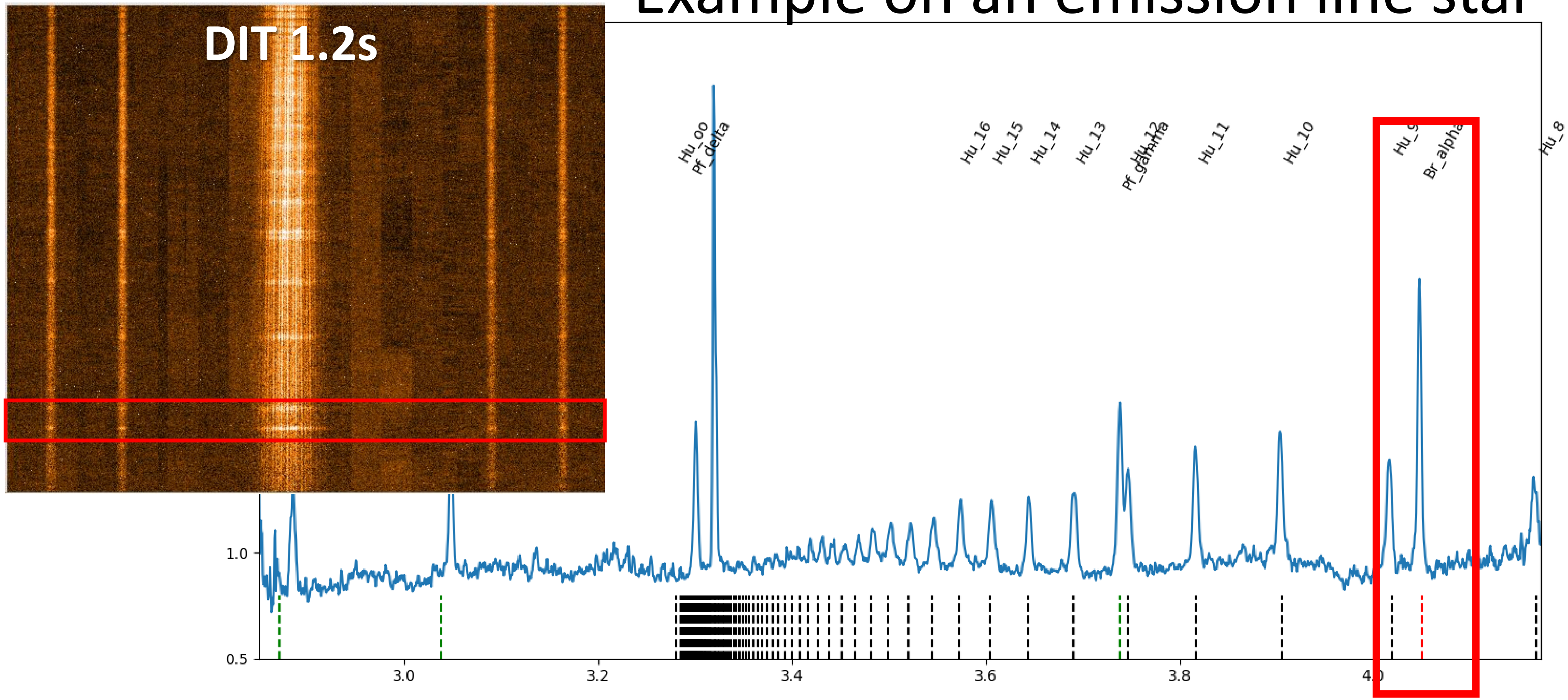


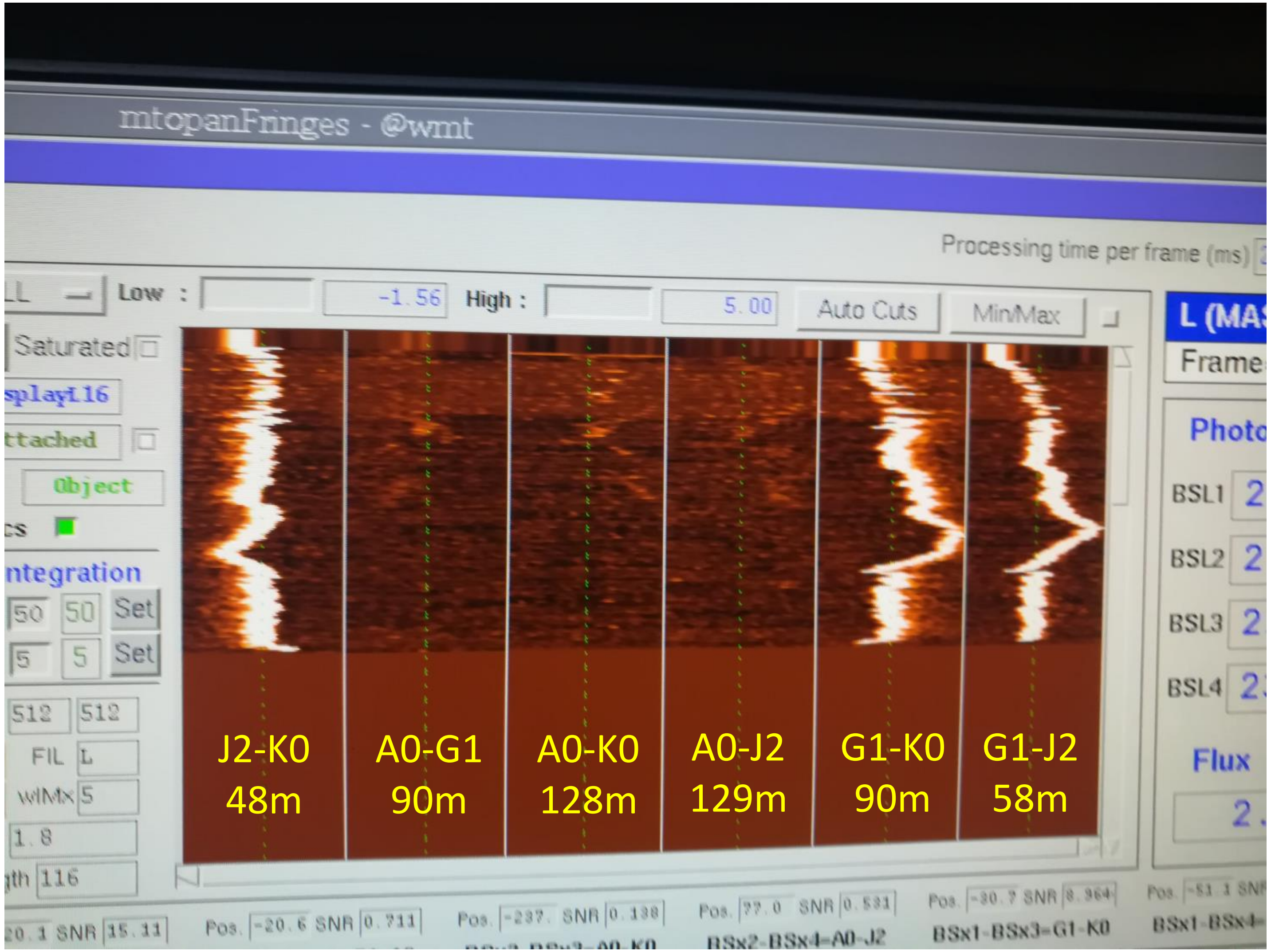
Could be extended using GRAVITY as external Fringe Tracker

⇔

GRAV4MAT

Tests on AGNs

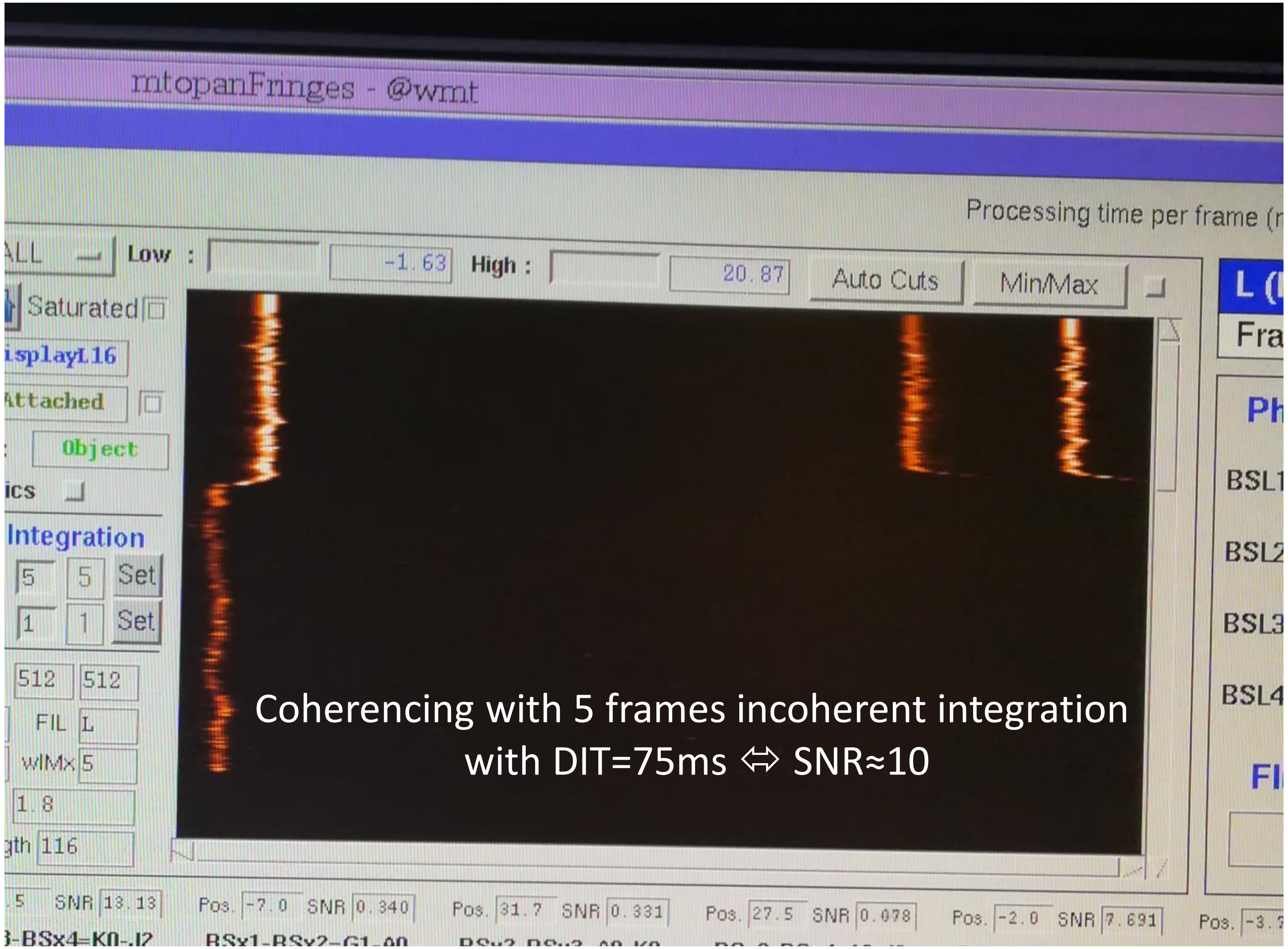
AT L-band Fringes acquisition



≈ 2Jy

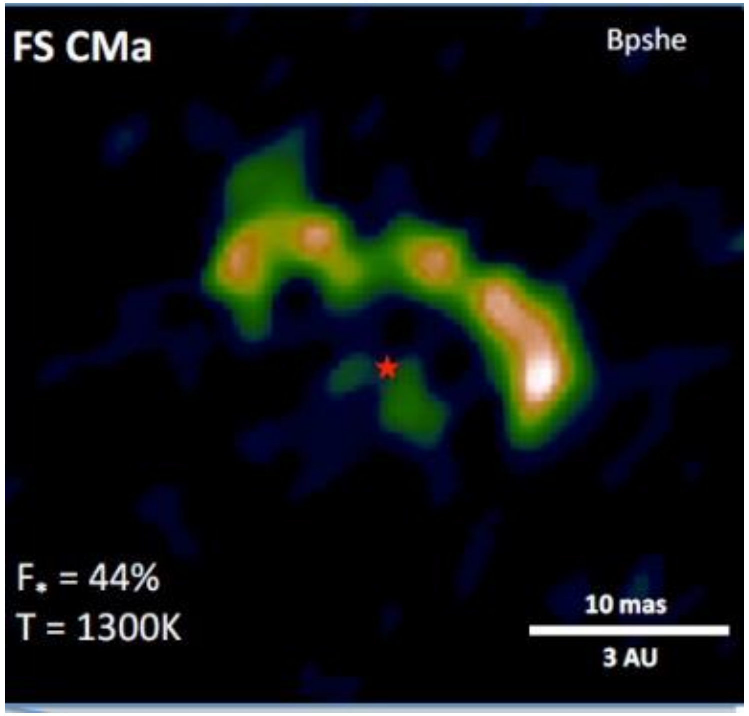
Tests on AGNs

AT L-band Fringes coherencing



≈ 2Jy

MATISSE First Image (December 2018)



PIONIER image of FS Cma (HD45677)
Circumstellar disk (either B[e] or Herbig)

Imaging Commissioning Run

10 nights of observation

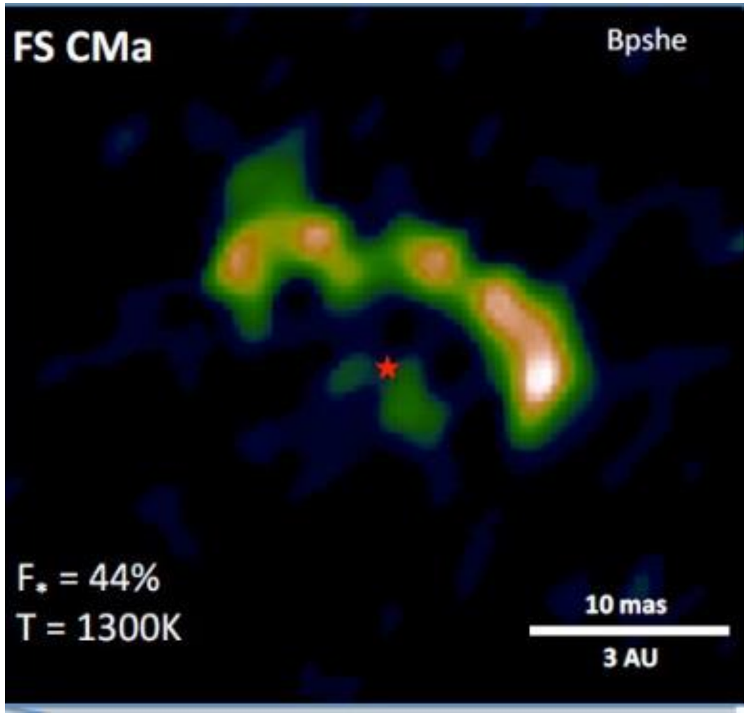
All 4 offered AT configurations :

- Small : 12-35m
- Medium : 40-105m
- Astrometric:58-129m
- Large : 90-132m

3 main targets (well studied) :

- FS CMa : YSO or B[e]? => circumstellar disk
- R Scl : AGB
- Betelgeuse : to test HR imaging capability

MATISSE First Image (December 2019)



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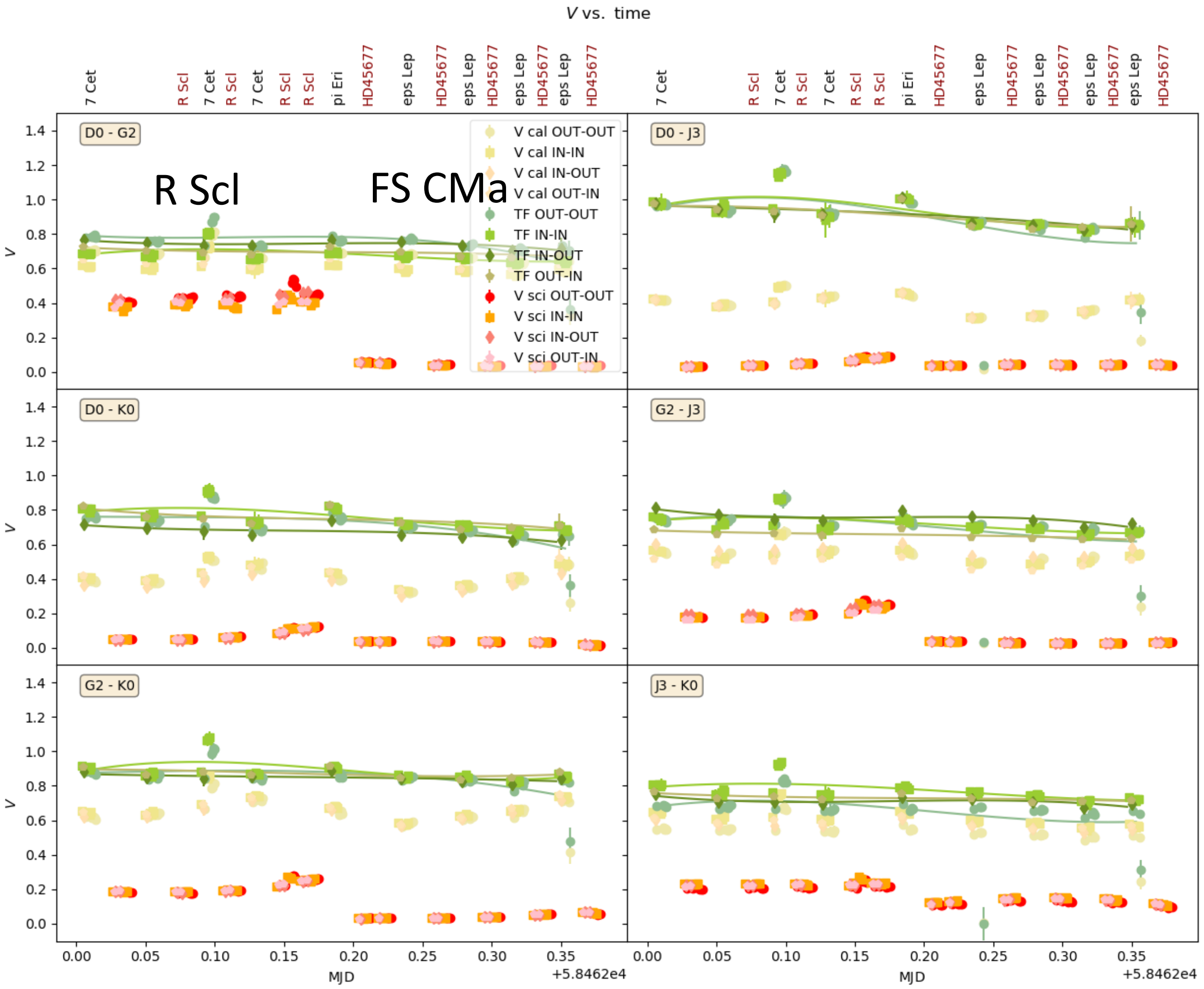
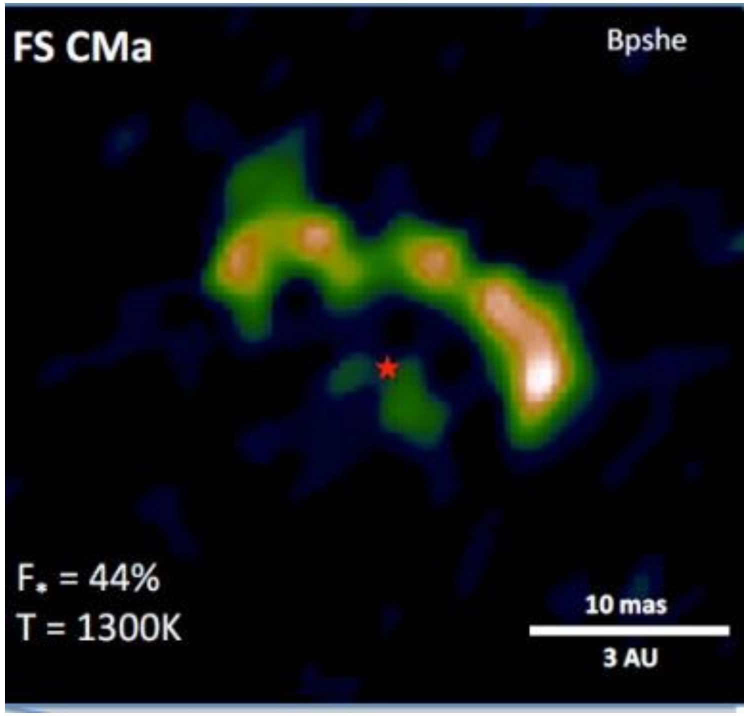


L-Band Transfer function in visibility

MATISSE First Image (December 2019)



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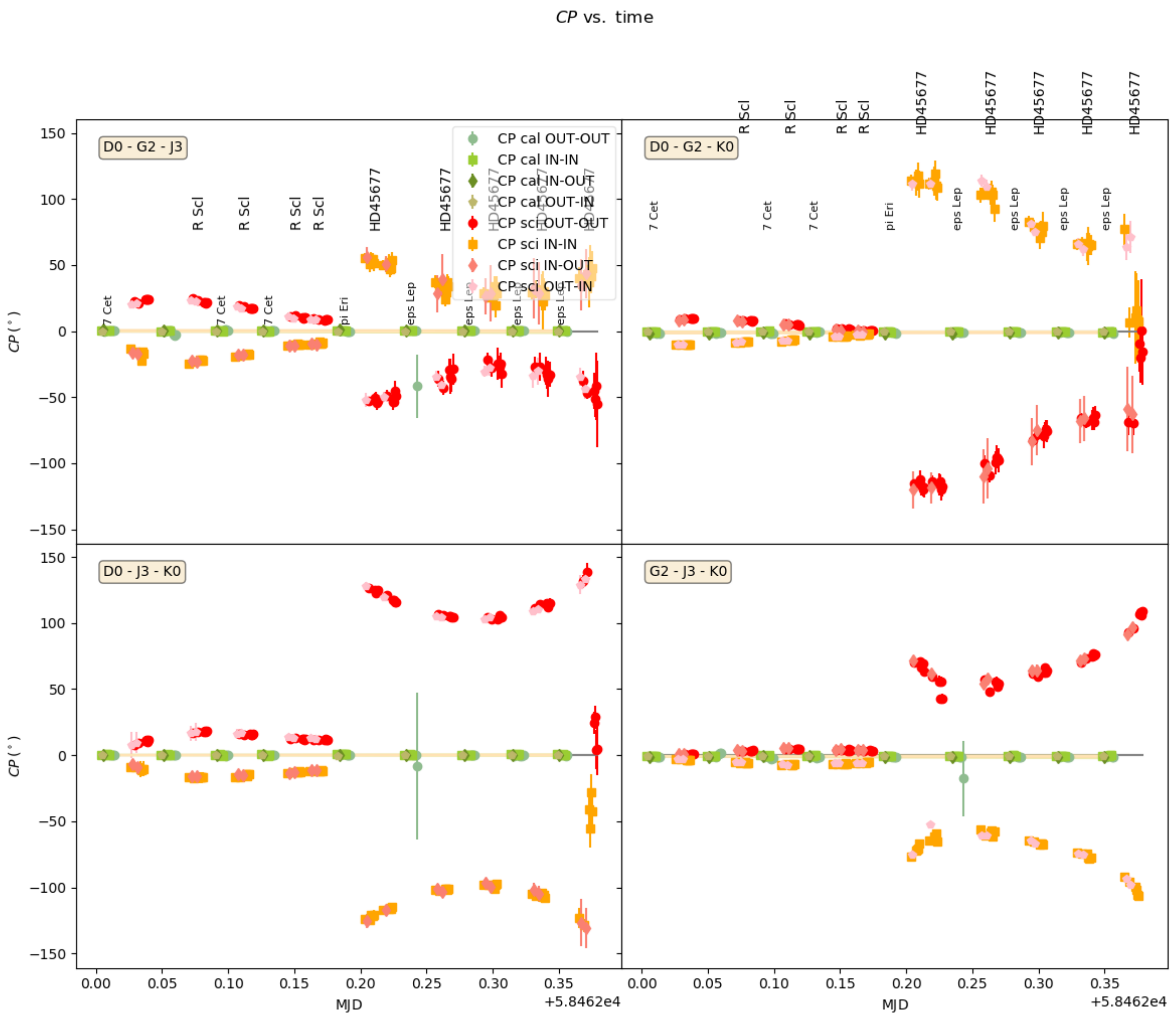
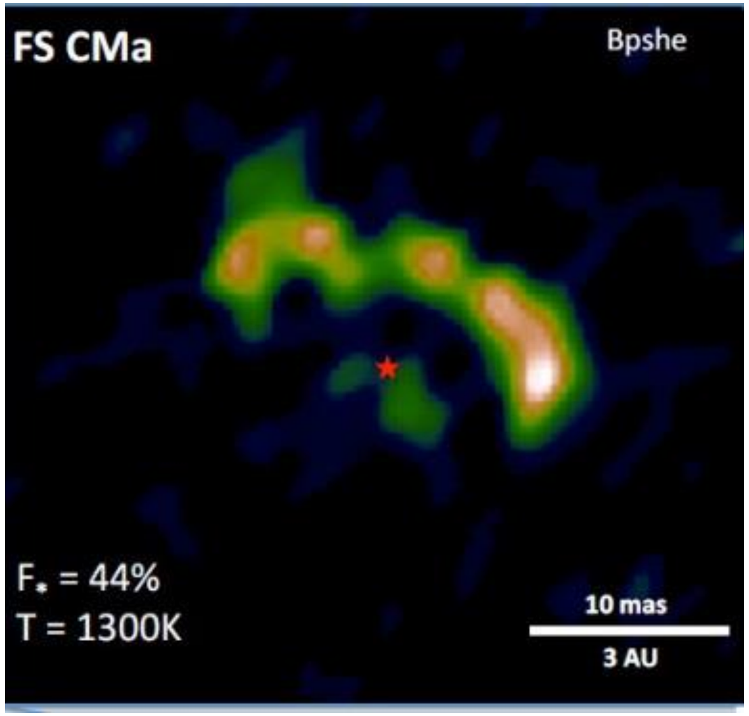


L-Band Transfer function in Closure Phase

MATISSE First Image (December 2019)



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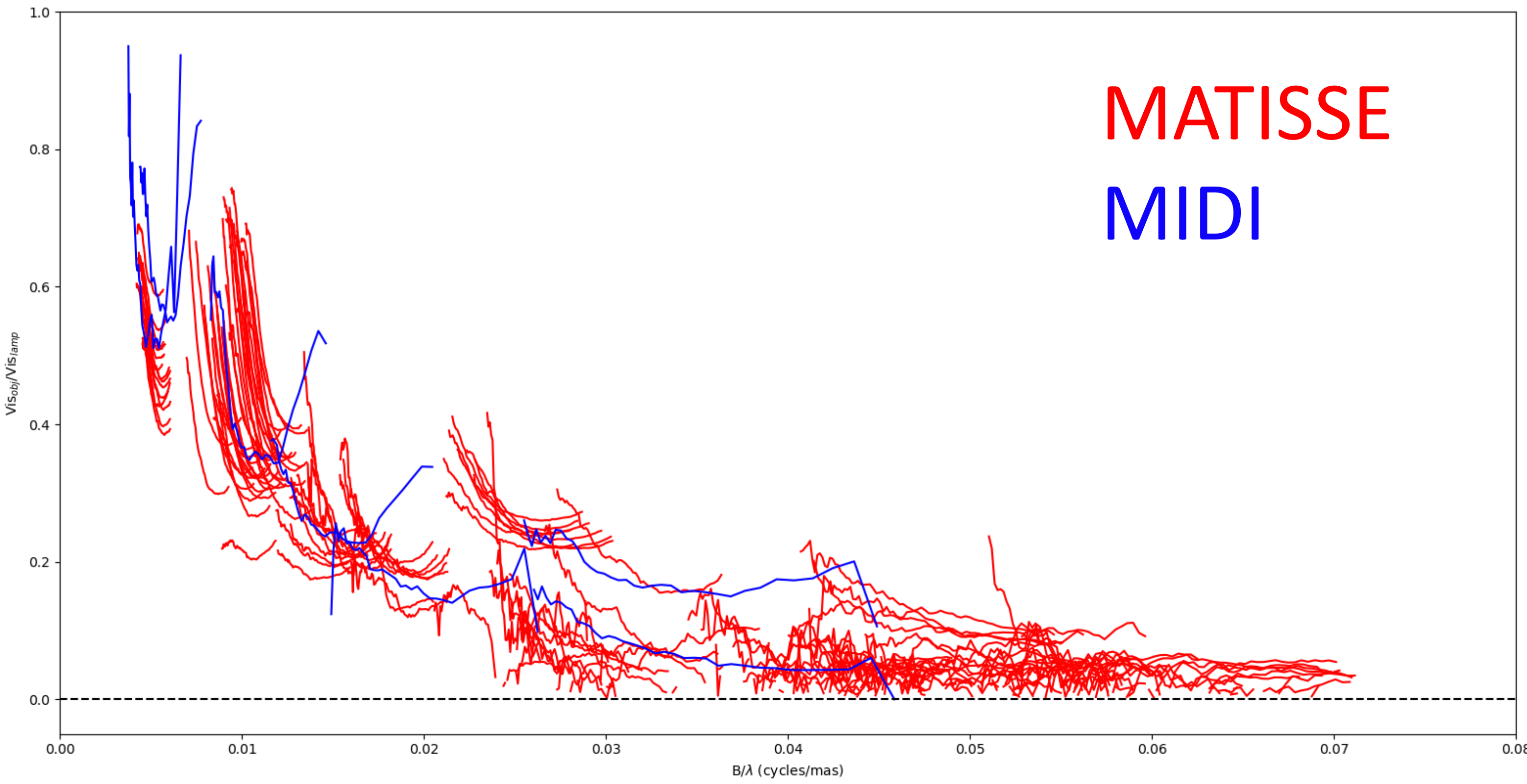
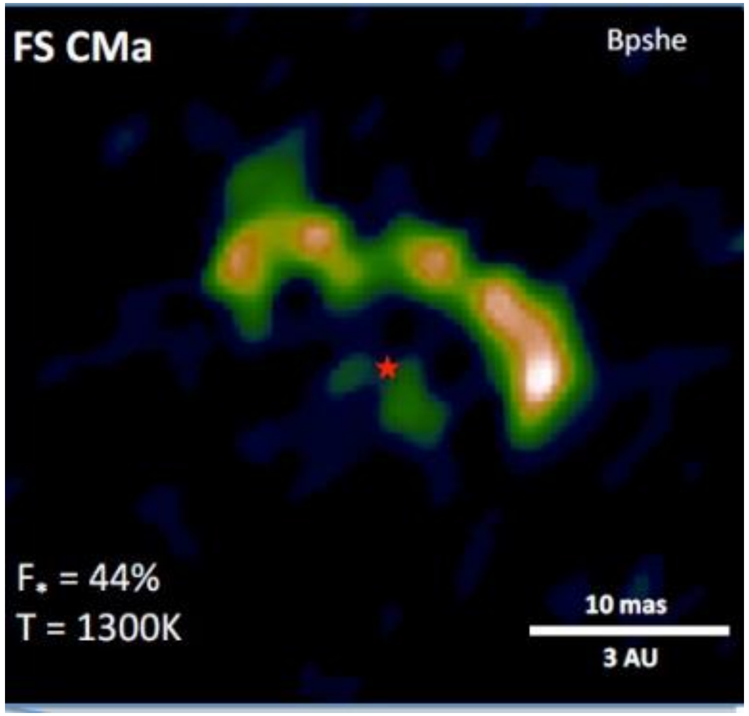


N-Band Calibrated V as funciton of spatial frequency

MATISSE First Image (December 2019)



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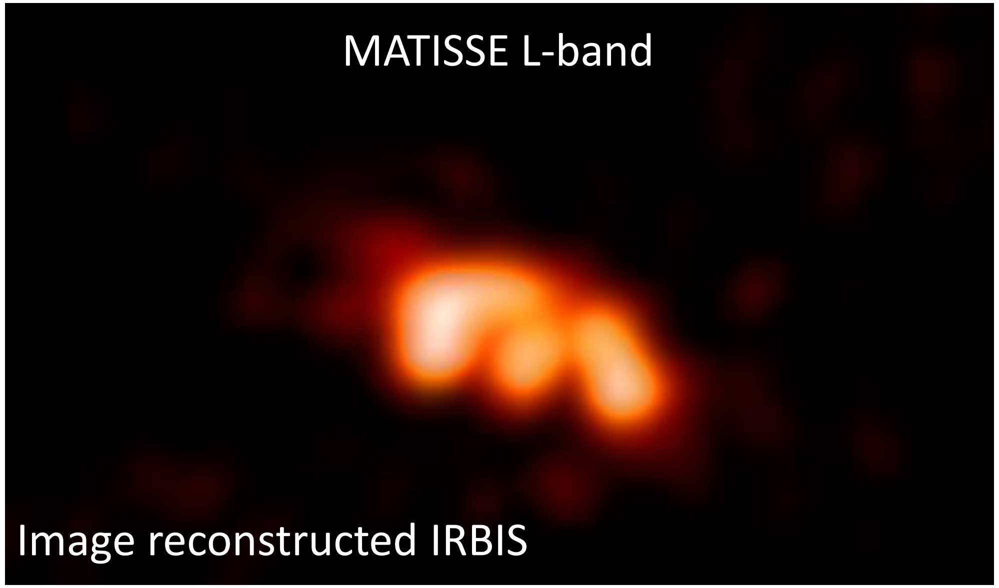

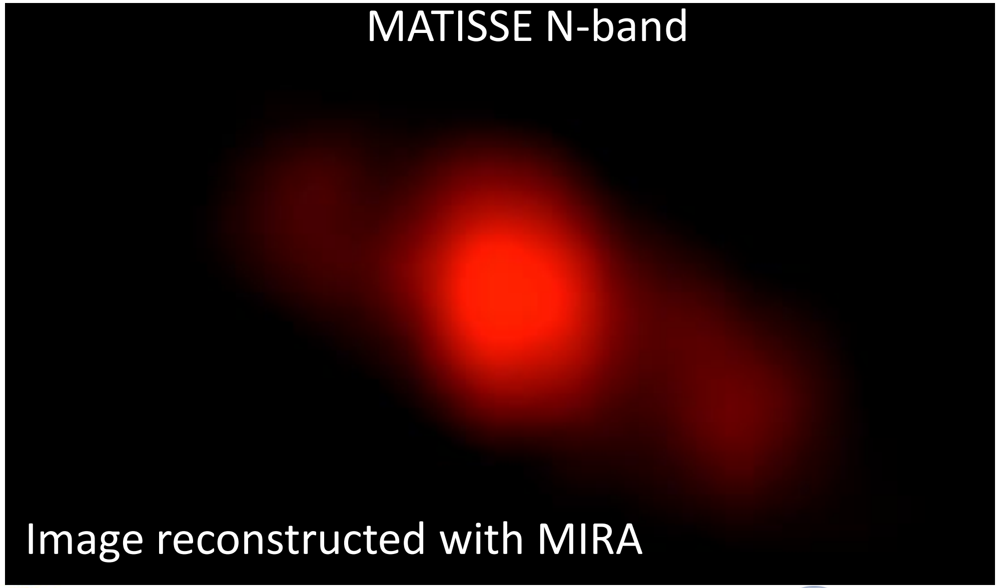

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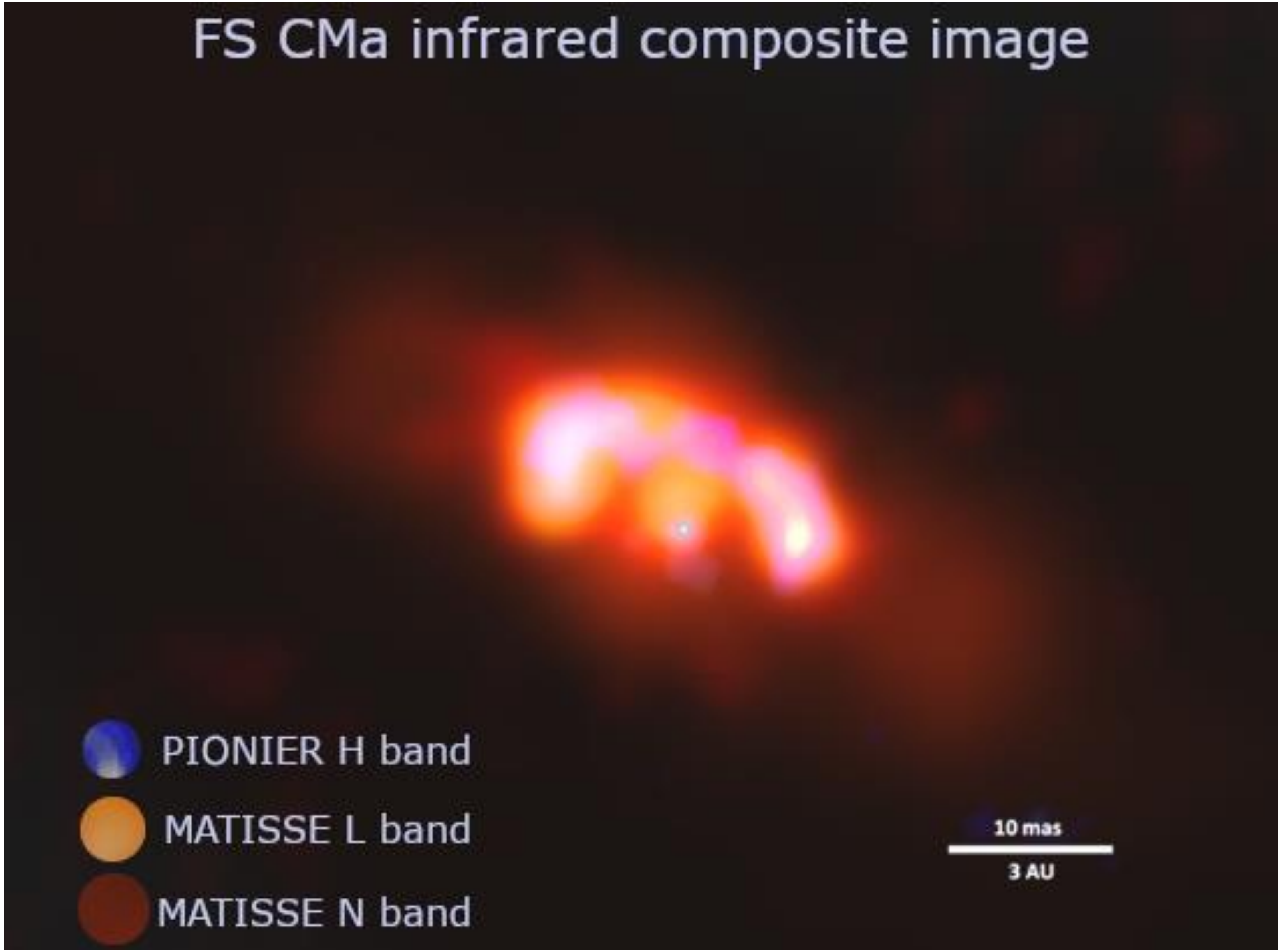
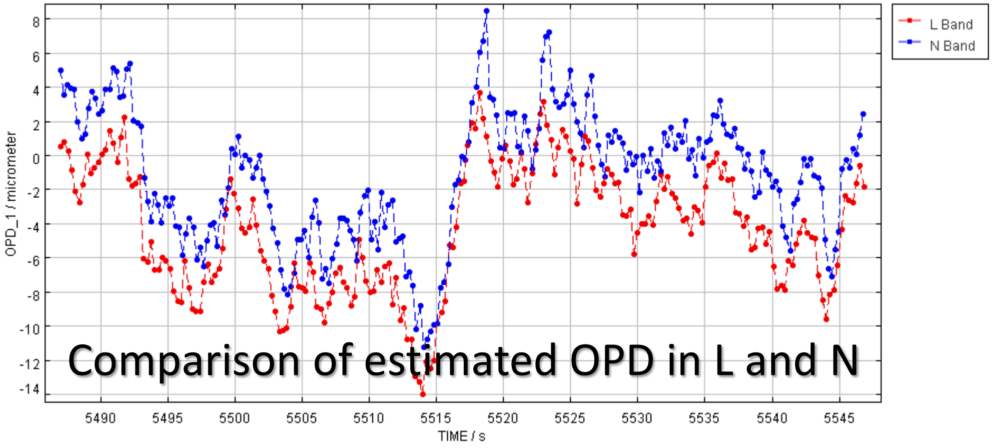


What's next?

MATISSE is now ready to do science:

- First observation from the consortium on March 21
- Instrument opened to the community on April 1st



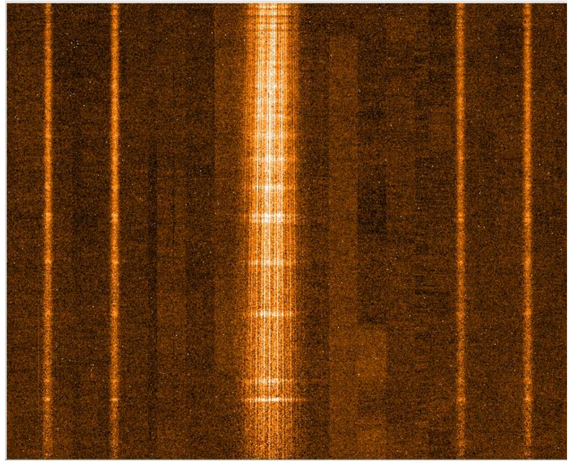
Comparison of estimated OPD in L and N

But many improvement are on their way :

- **Coherent Integration in N using L-band estimated OPD**
  Coherent integration up to several minutes
  Should dramatically improve N-band sensibility

- **GRAV4MAT : using Gravity-FT for MATISSE**
  Increase L-band DIT beyond 1s
  Especially important for L-band MR, HR, and VHR mode

- **Very-high resolution mode : R=4000**
  Kinematics in Brα & CO lines 4.6-4.7



This is an happy Astronomer!

Observations should always be that way…