Data and calibration of AMBER / VLTI

A stronomical M ulti BE am R ecombiner / V ery L arge T elescope I nterferometer

Florentin Millour

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And the A.M.BE.R. consortium

Université Nice Sophia Antipolis — Grenoble I Université Joseph Fourier, Sciences, Technologie, Médecine — Observatoire de la Côte d'Azur — Max-Planck-Institut für Radioastronomie — Osservatorio Astrofisico di Arcetri — Institut National des Sciences de l'Univers INSU

Consortium website : http://amber.obs.ujf-grenoble.fr

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Arezki Brahim, Aristidi Eric, Baffa Carlo, Beckmann Udo, Behrend Jan,
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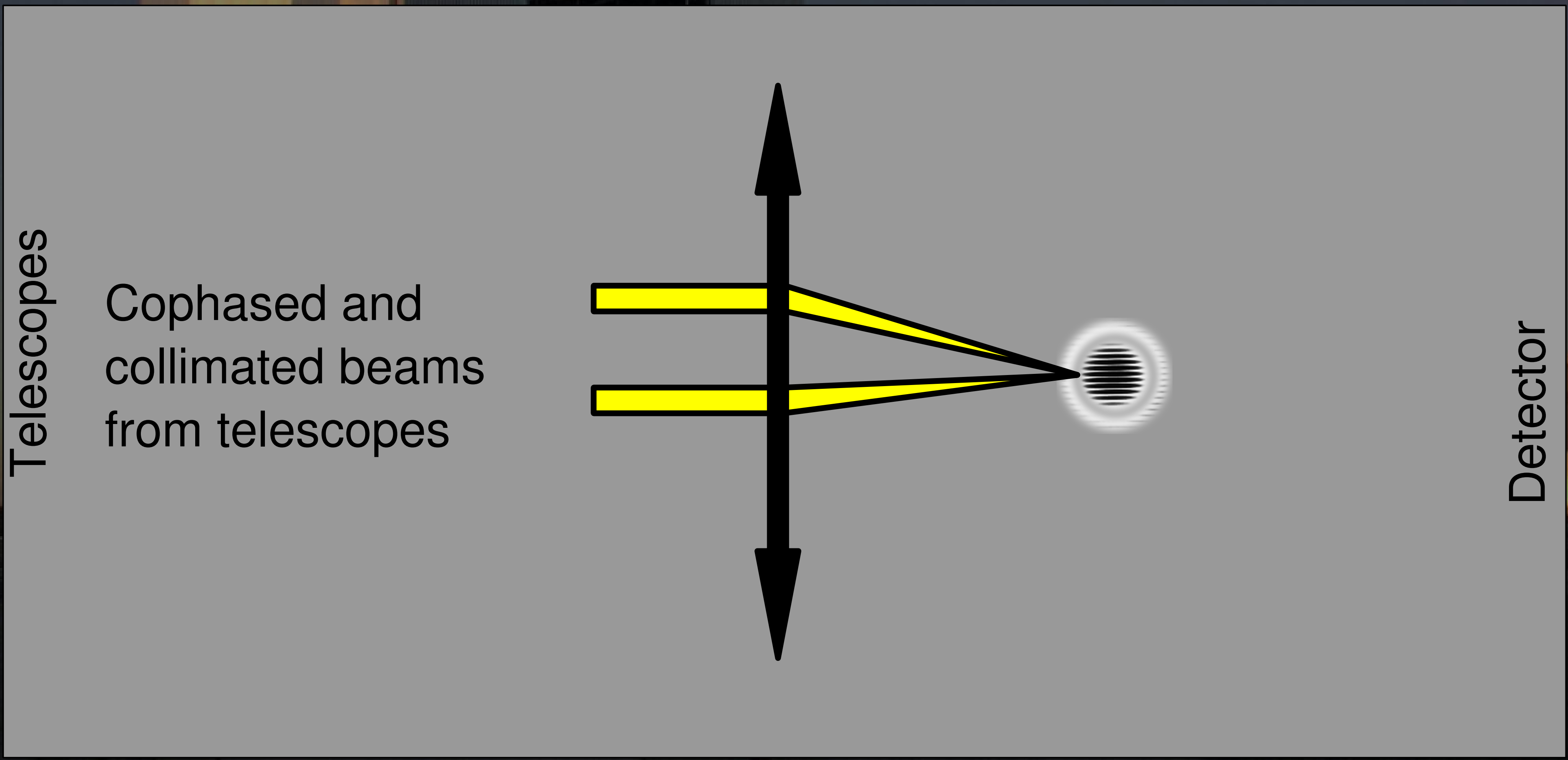
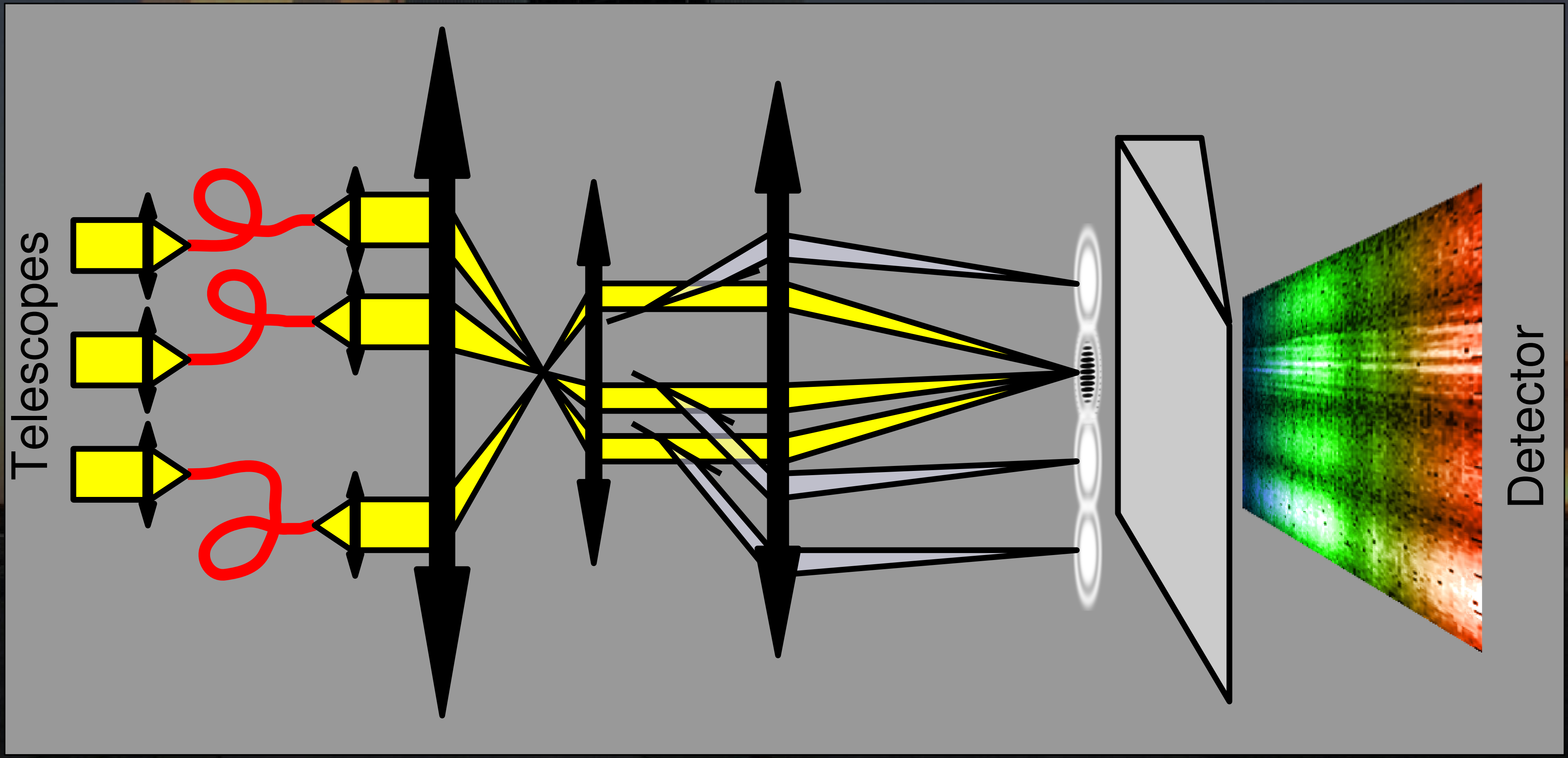
Pacini Franco, Perraut Karine, Perrier Christian, Petrov Romain, Puget Pascal,
Rabbia Yves, Rebattu Sylvestre, Reynaud François, Richichi Andrea, Robbe Sylvie,
Roussel Alain, Sacchettini Michel, Salinari Piero, Salvati Marco, Schertl Dieter,
Solscheid Walter, Stee Philippe, Stefanini Paolo, Tallon-Bosc Isabelle, Tallon Michel,
Tasso Daniel, Tatulli Éric, Testi Leonardo, Vakili Farrokh, Valtier Jean-Claude,
van der Lühe Oskar, Vannier Martin, Ventura Noël, Weigelt Gerd, Zins Gérard

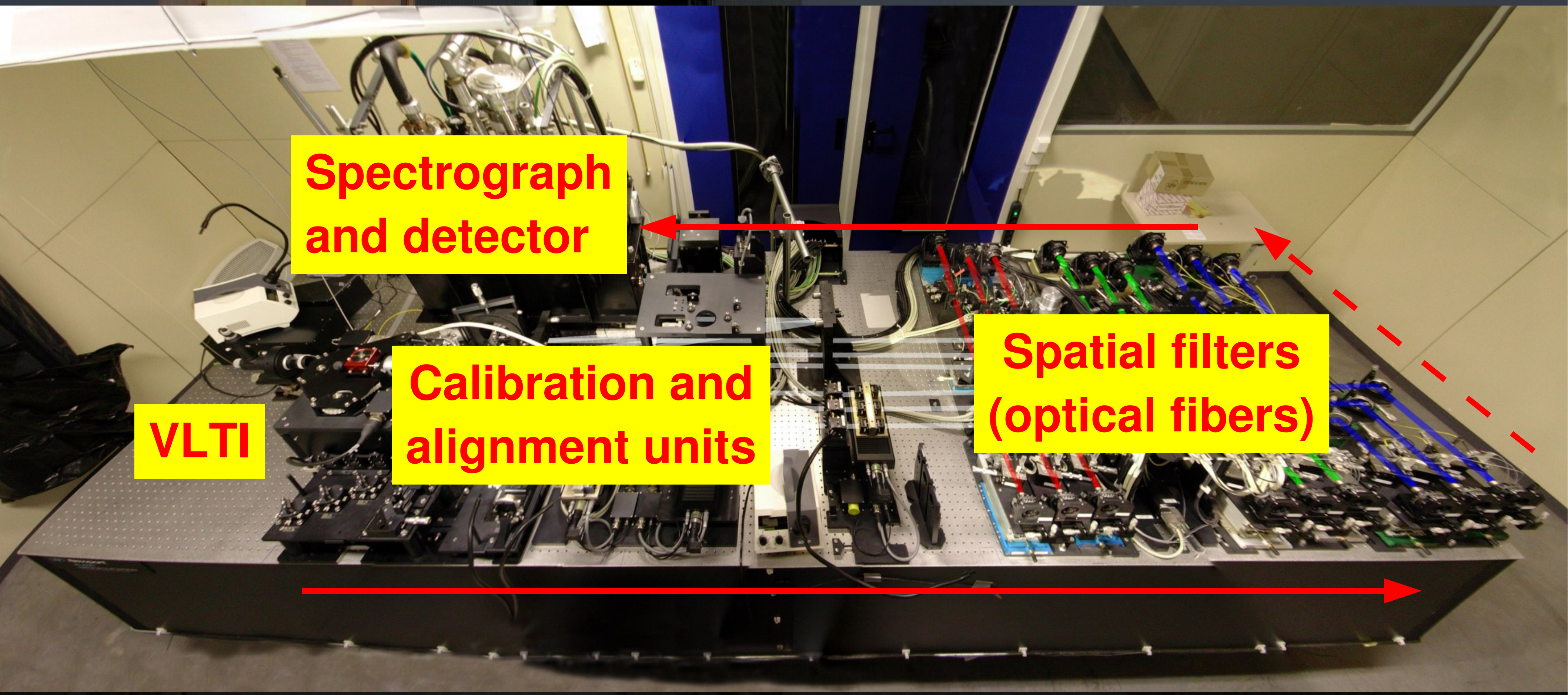
"Basic" interferometer



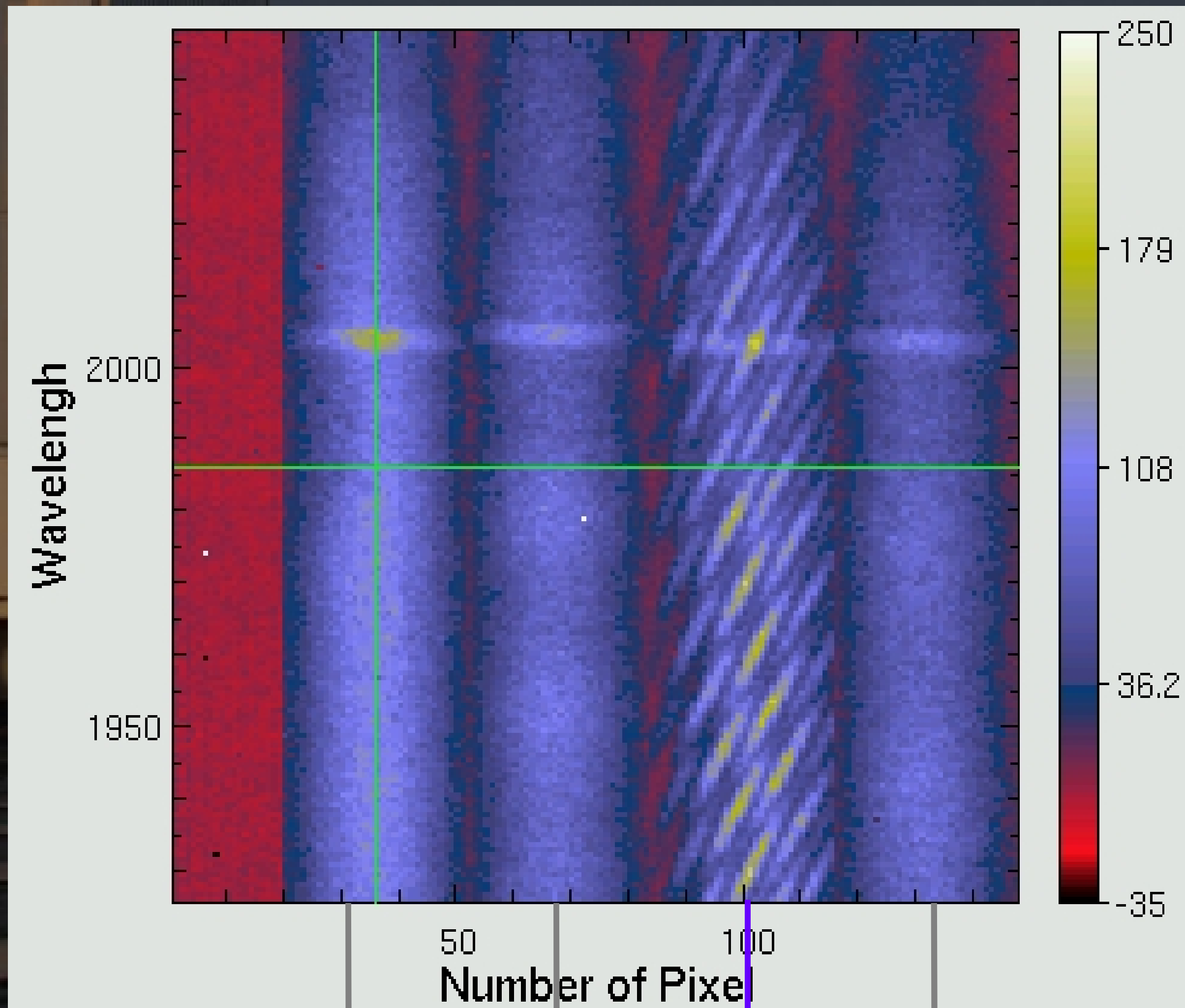
3T monomode spectro-interferometer



AMBER


Spectrograph and detector
Calibration and alignment units
VLTI
Spatial filters (optical fibers)

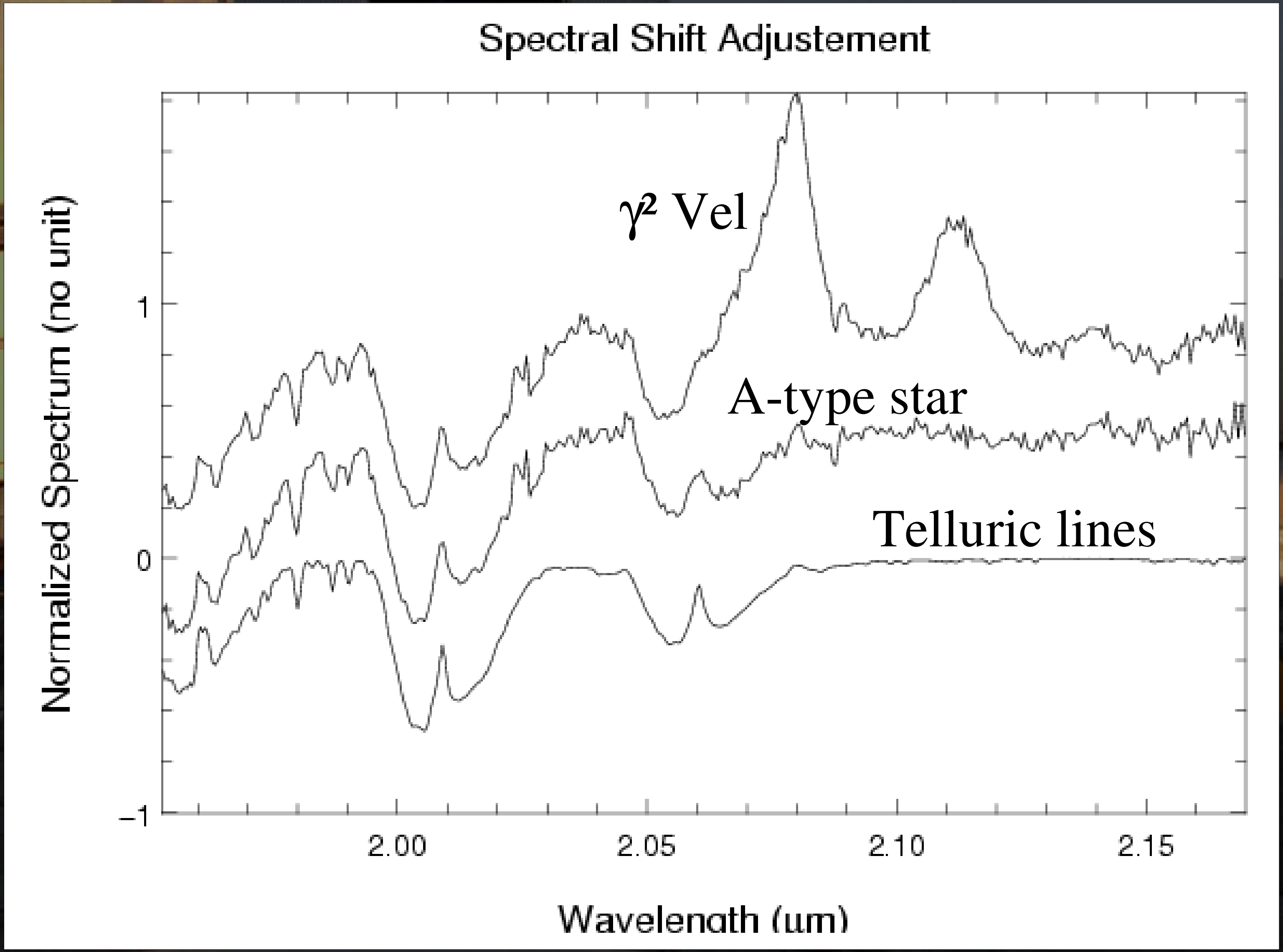
The AMBER raw data



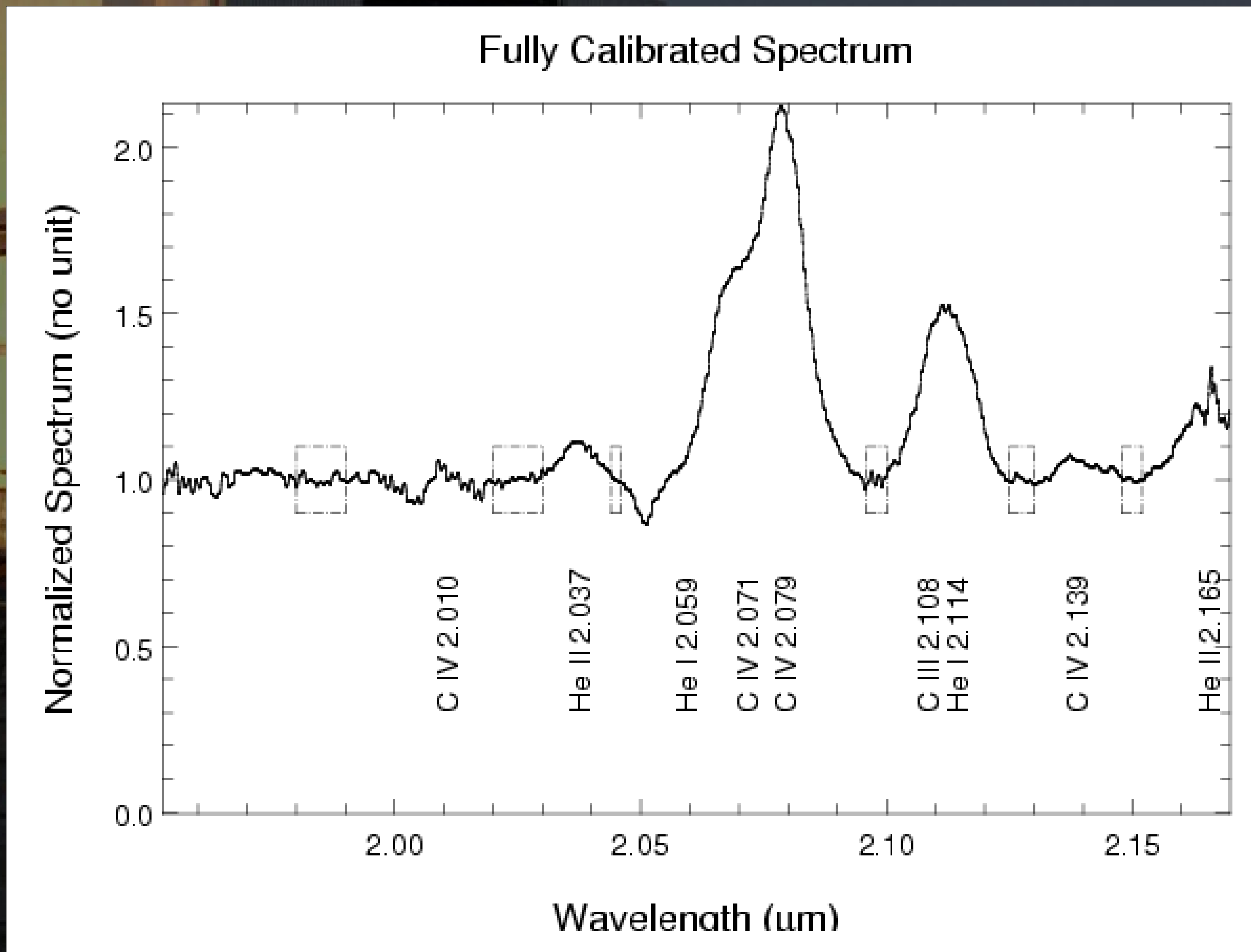
Photometric beams

Interferometric beam

Spectral calibration



Spectral calibration



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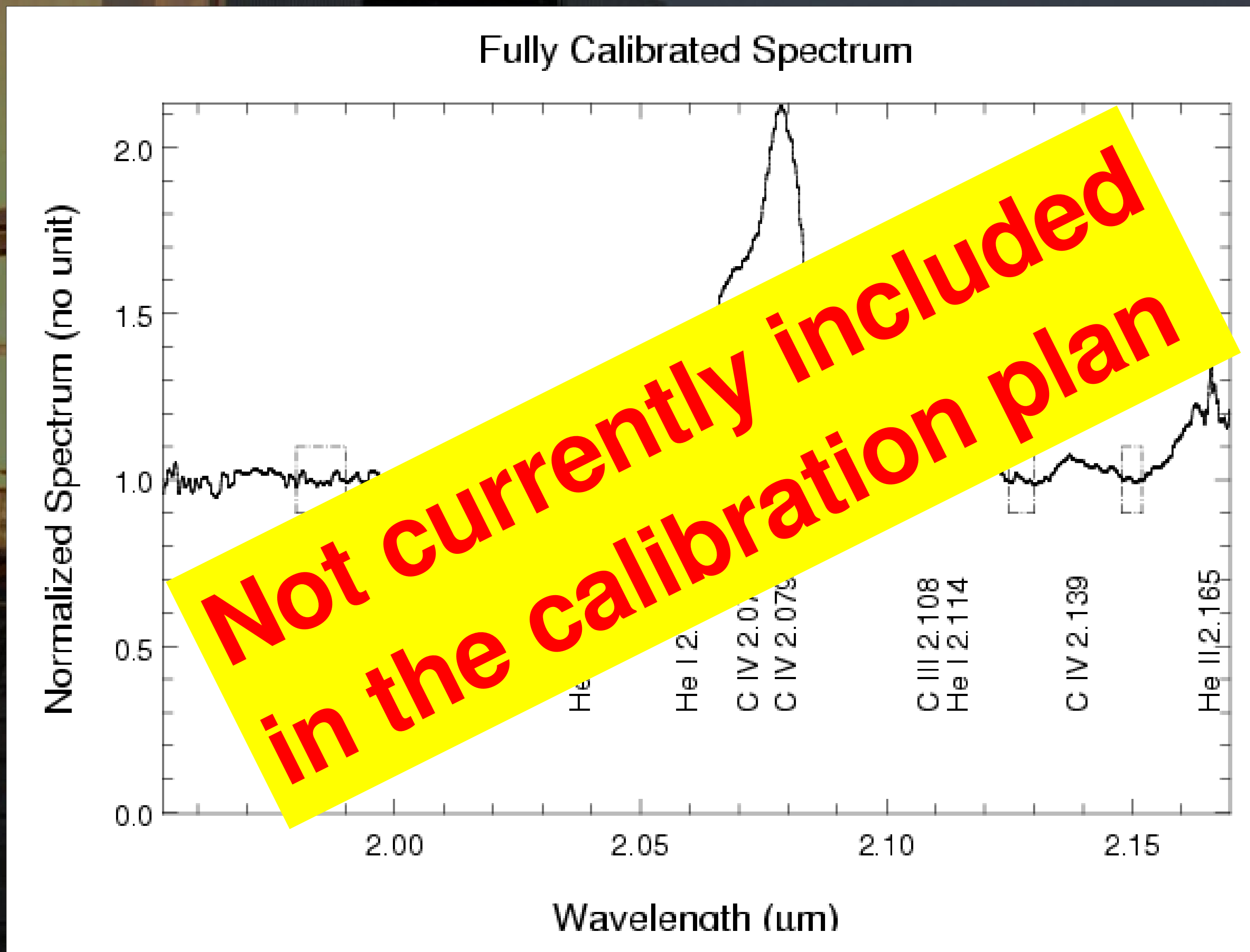
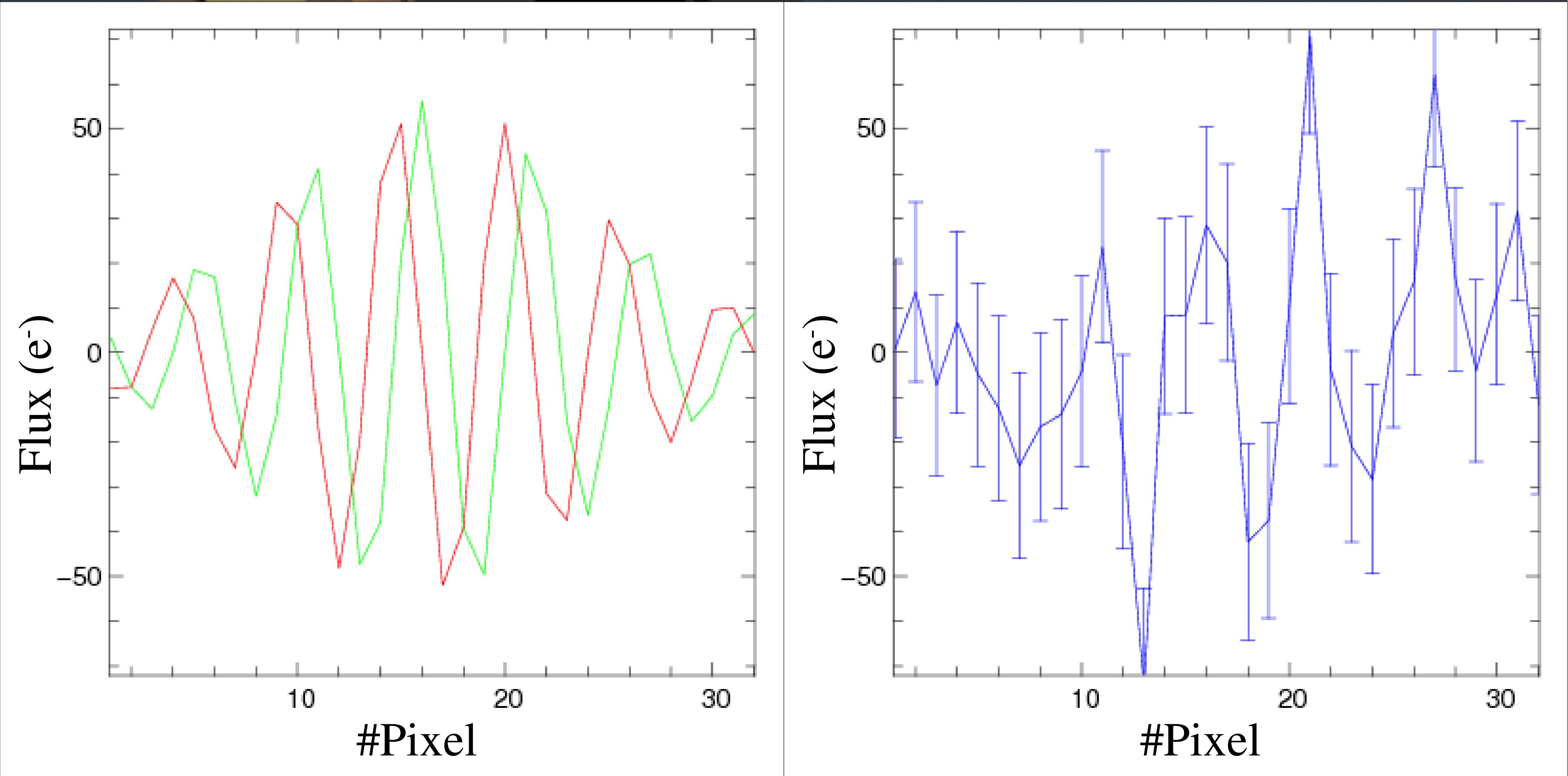
Spectral calibration



The P2VM algorithm



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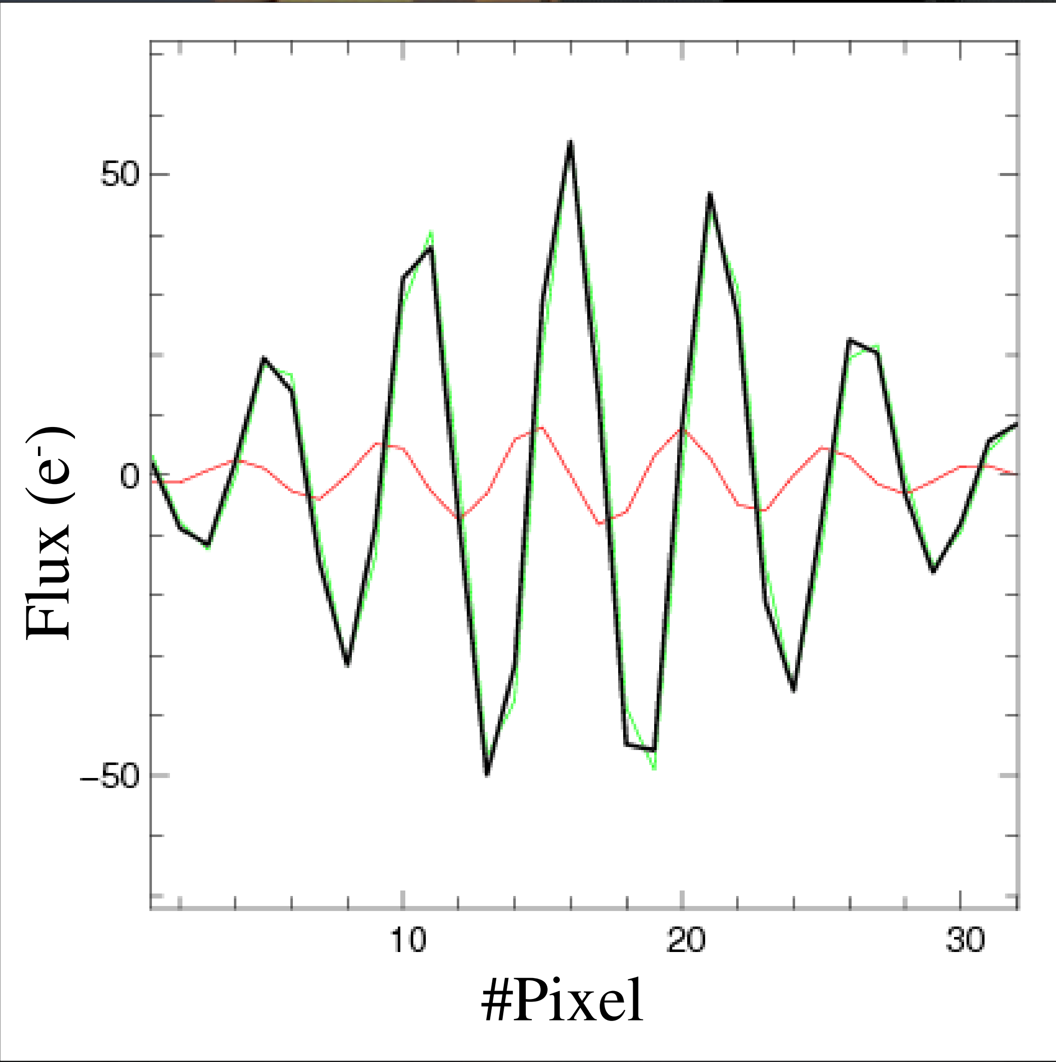

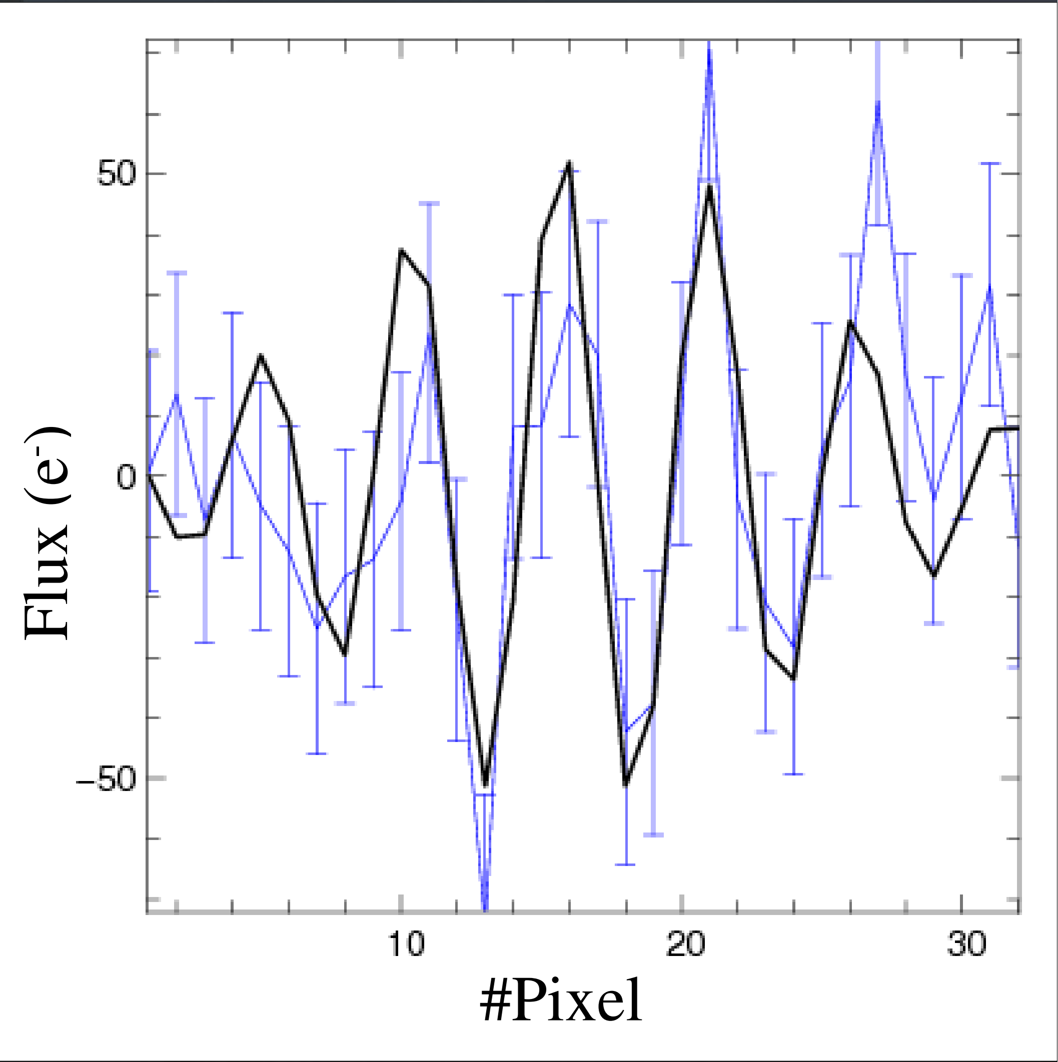

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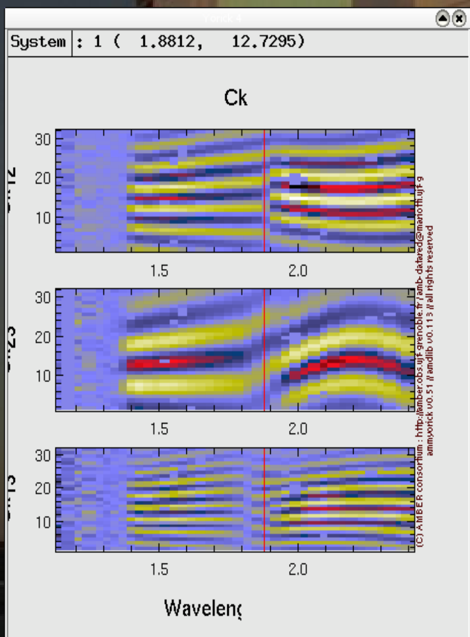
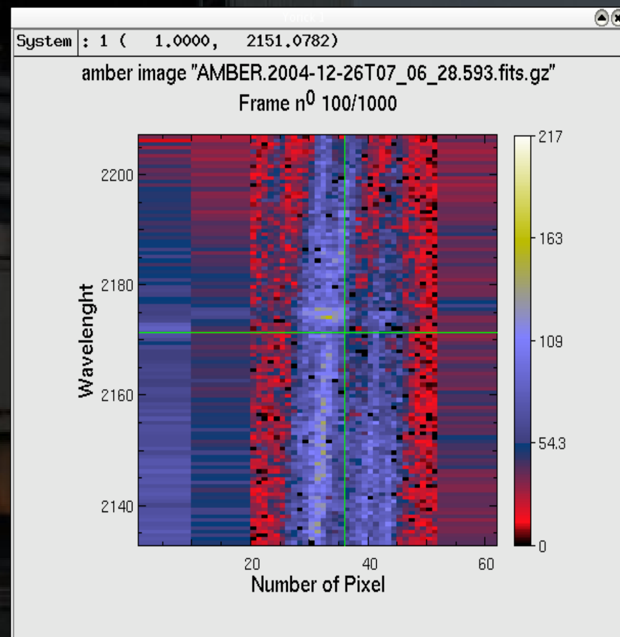


P2VM
"Instrumental fringes"

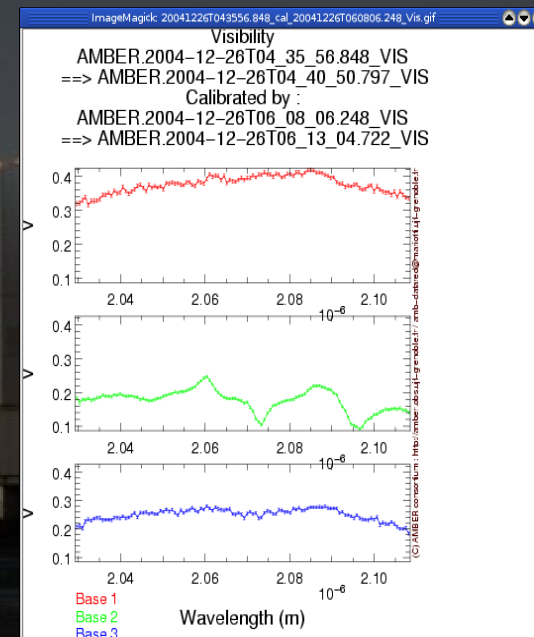
X



"cleaned" data

Matrix multiplication

=



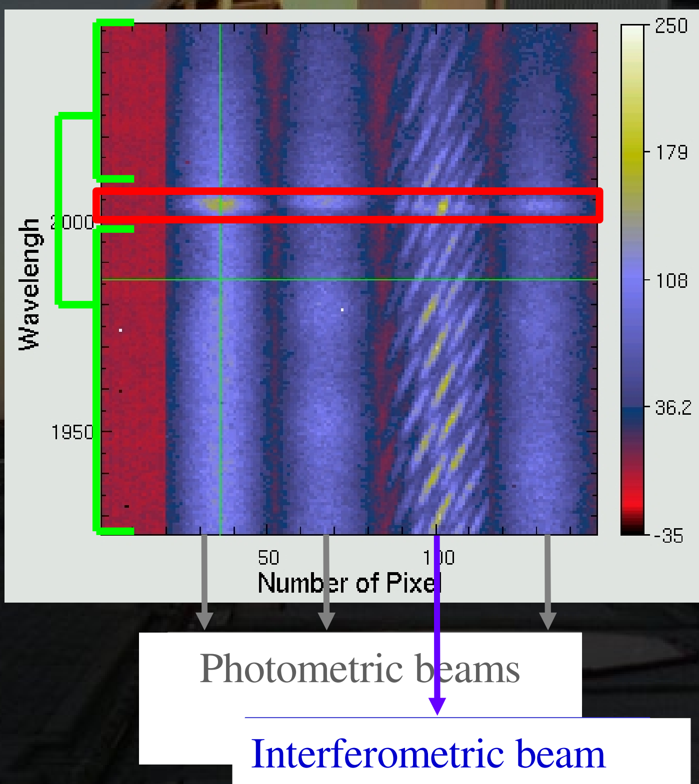
Observables
(Complex coherent flux)

AMBER observables

Complex coherent flux :

$$C^{i,j}(\lambda) = 2 N V_T \mu$$

measured on M frames



Spectrum : $S(\lambda) = N(\lambda)$

Visibility : $V^{i,j}(\lambda) = |C^{i,j}(\lambda)| / N(\lambda)$

Phase closure : $\Psi^{123}(\lambda) = \mathrm{atan}\langle C^{1,2} C^{2,3} C^{*1,3} \rangle$

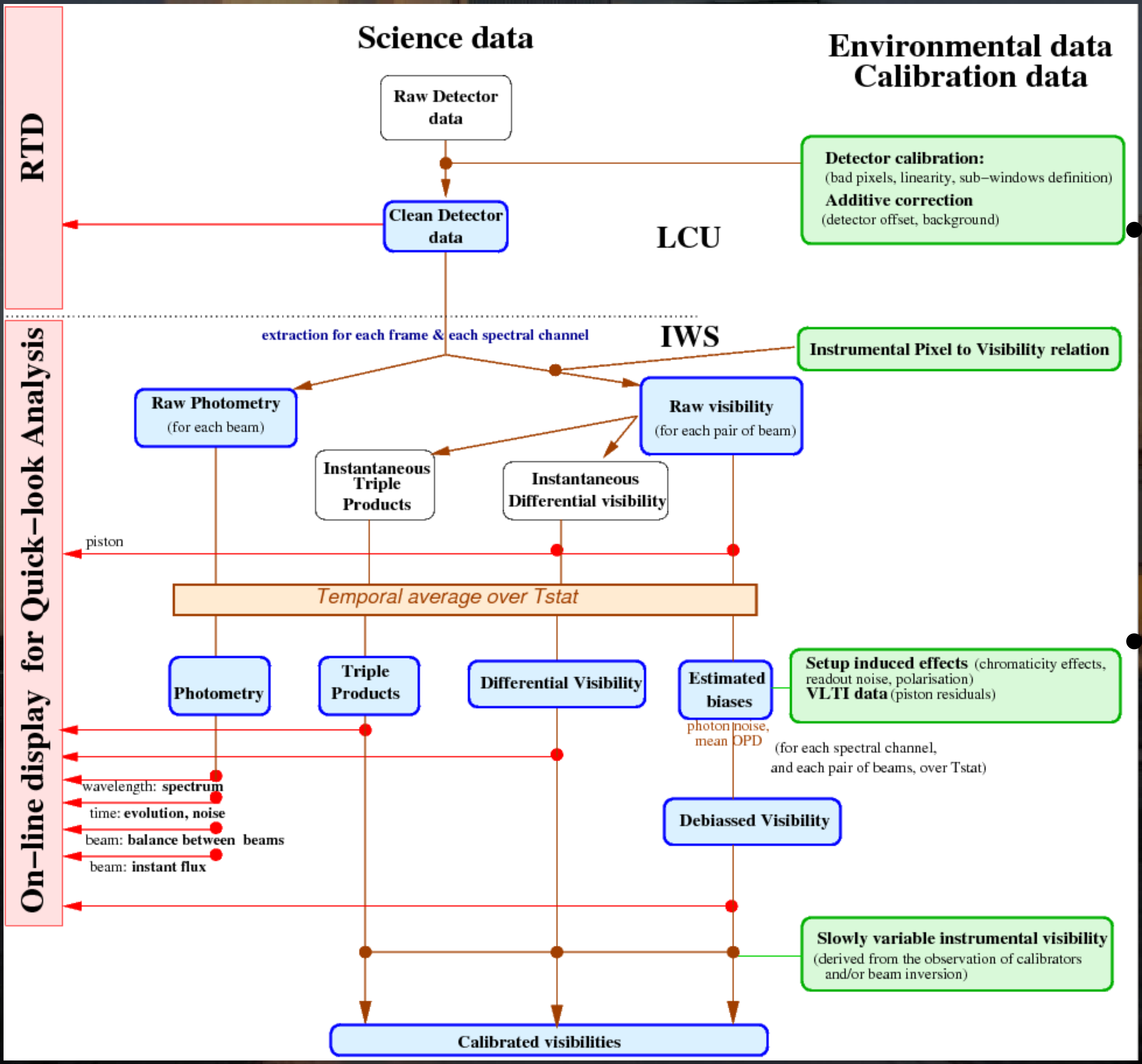
Diff. phase : $\Phi^{i,j}_{diff}(\lambda)$

Diff. visibility : $V^{i,j}_{diff}(\lambda)$

"Phase closure" of diff. phases :

$$\Psi^{123}_{diff}(\lambda) = \Phi^{1,2}_{diff}(\lambda) + \Phi^{2,3}_{diff}(\lambda) + \Phi^{3,1}_{diff}(\lambda)$$

The amdlib library



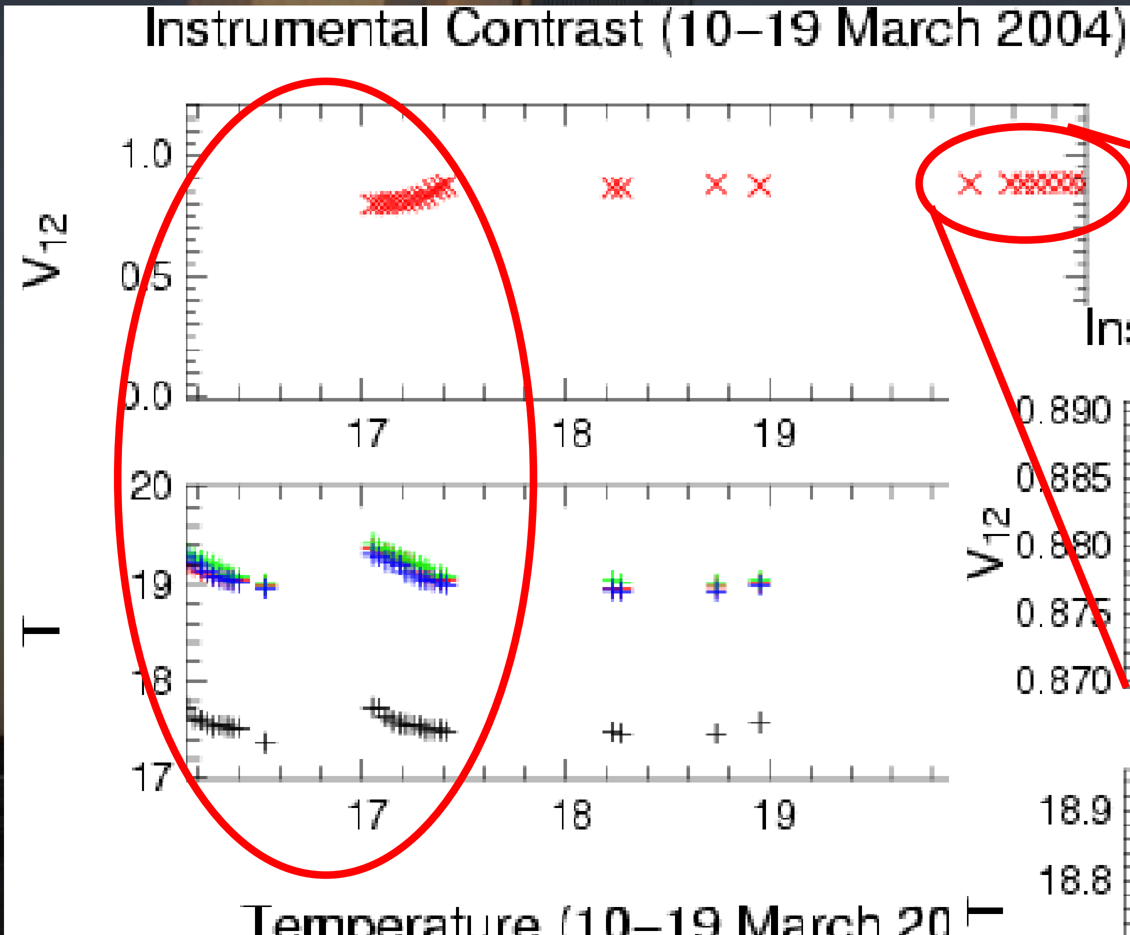
- Handles all the data reduction steps, both online and offline
- GUI : Gasgano, ammYorick, GreG

The P2VM algorithm

Is valid IF :

- the instrument is stable enough between calibration and observations
- SNR on the P2VM is enough
- The spectral channels are thin enough
- The detector cosmetics is well enough known
- The wavelength calibration is OK

The P2VM algorithm



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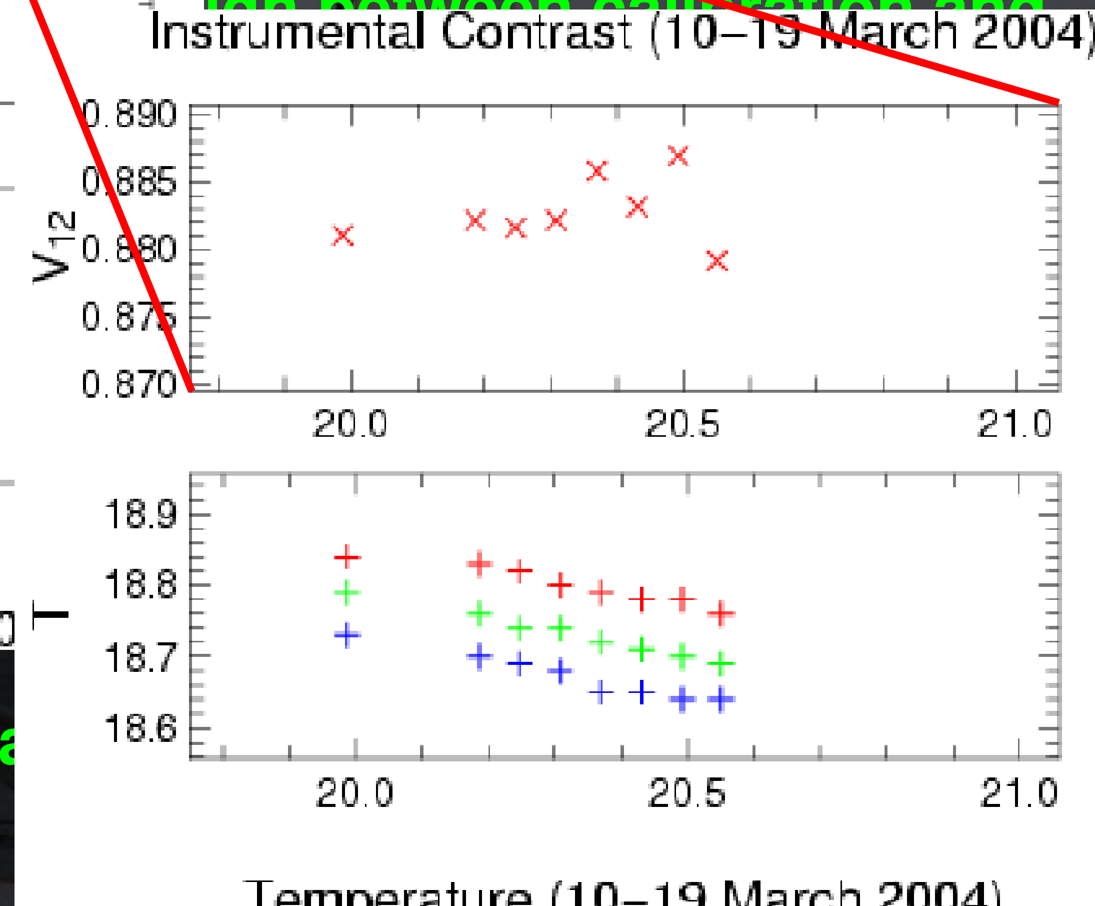

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F. Millour, ESO, 26/01/07

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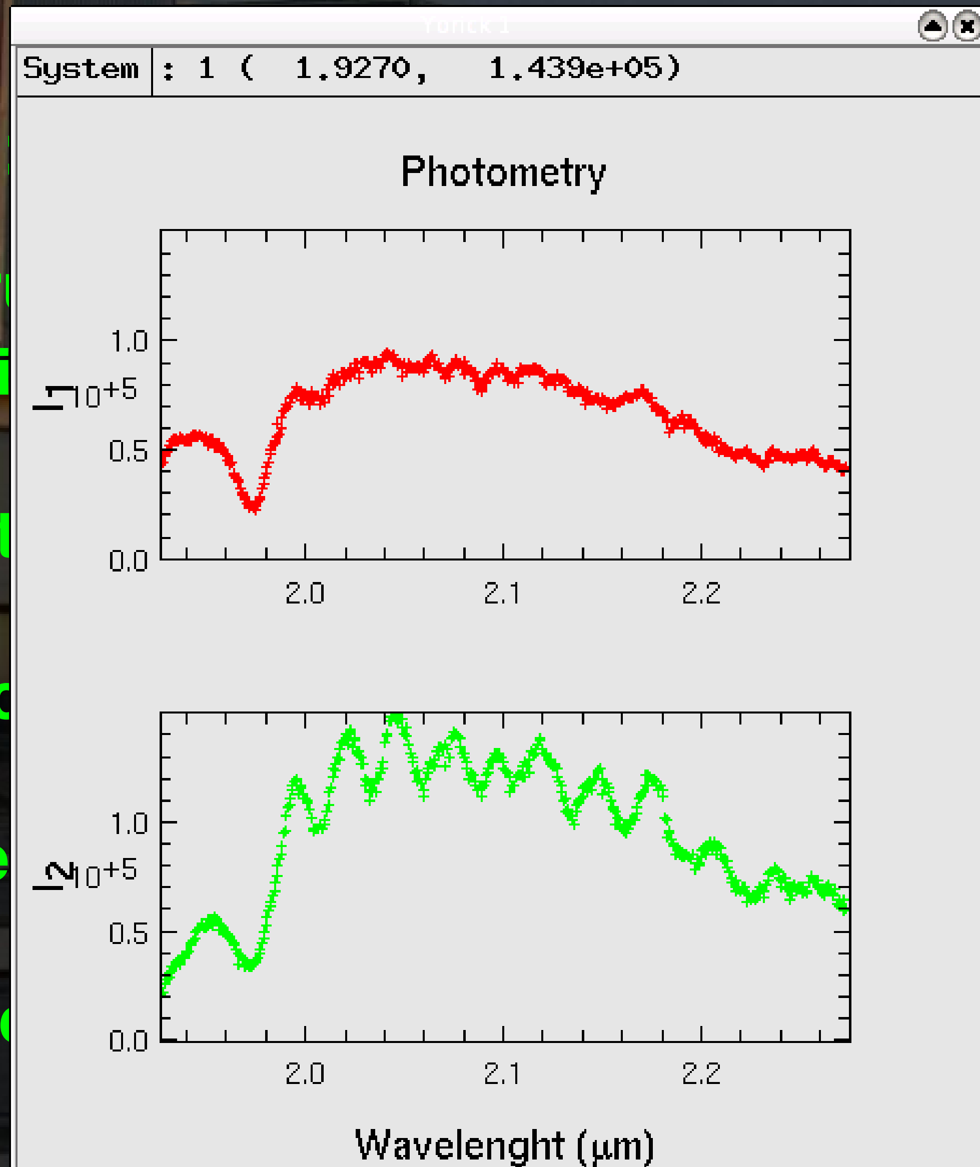

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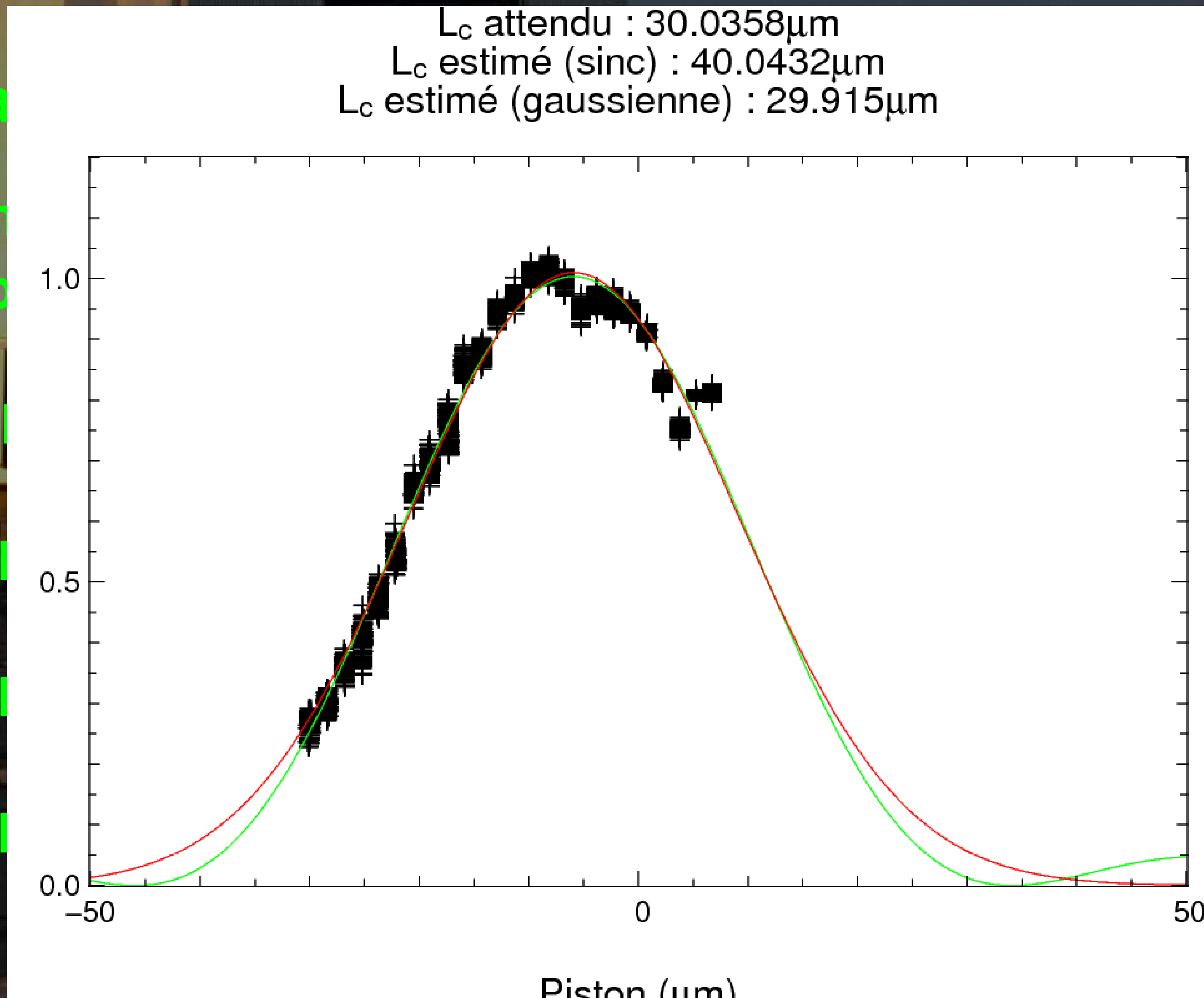

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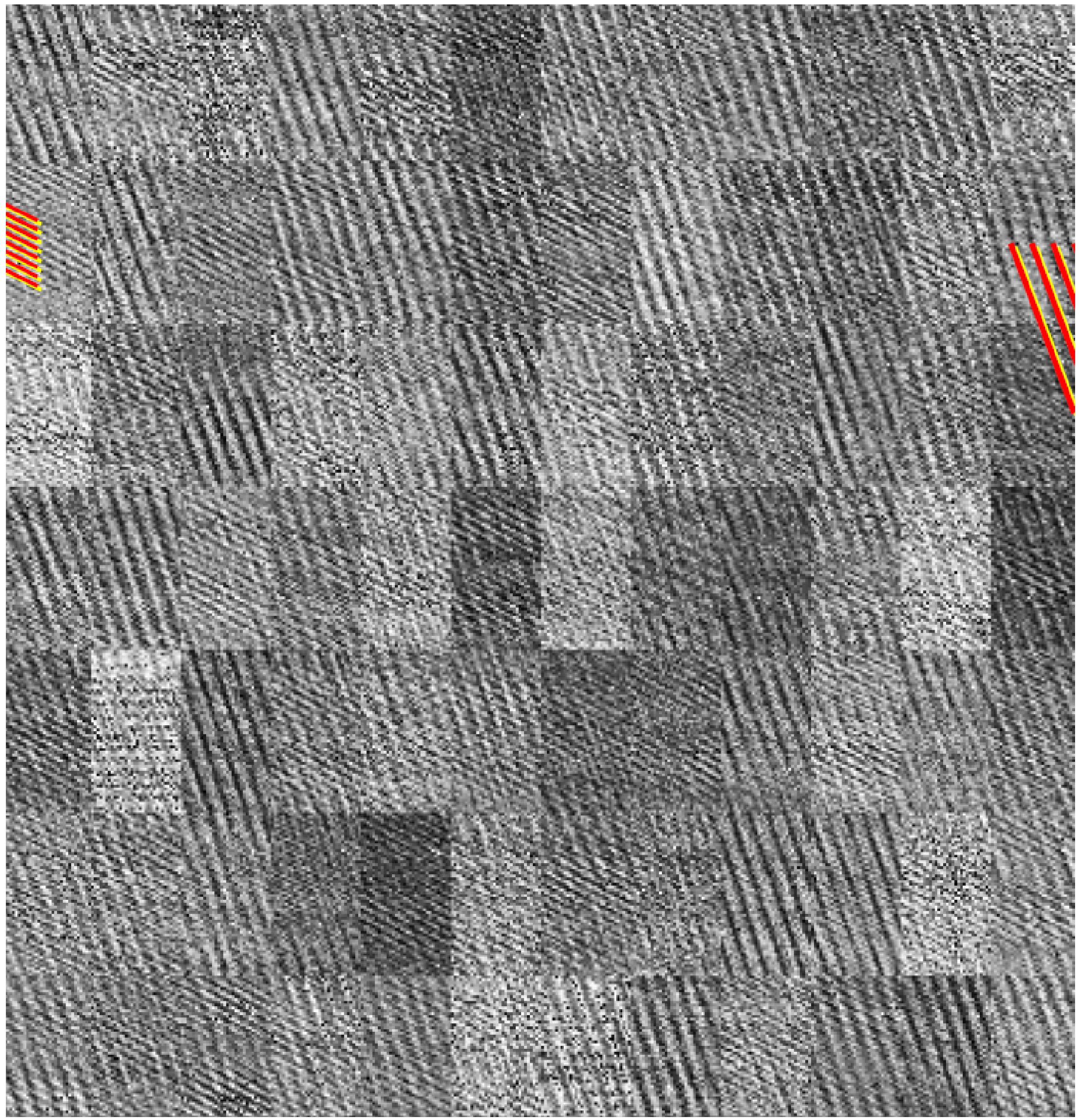

G. Li Causi 2006

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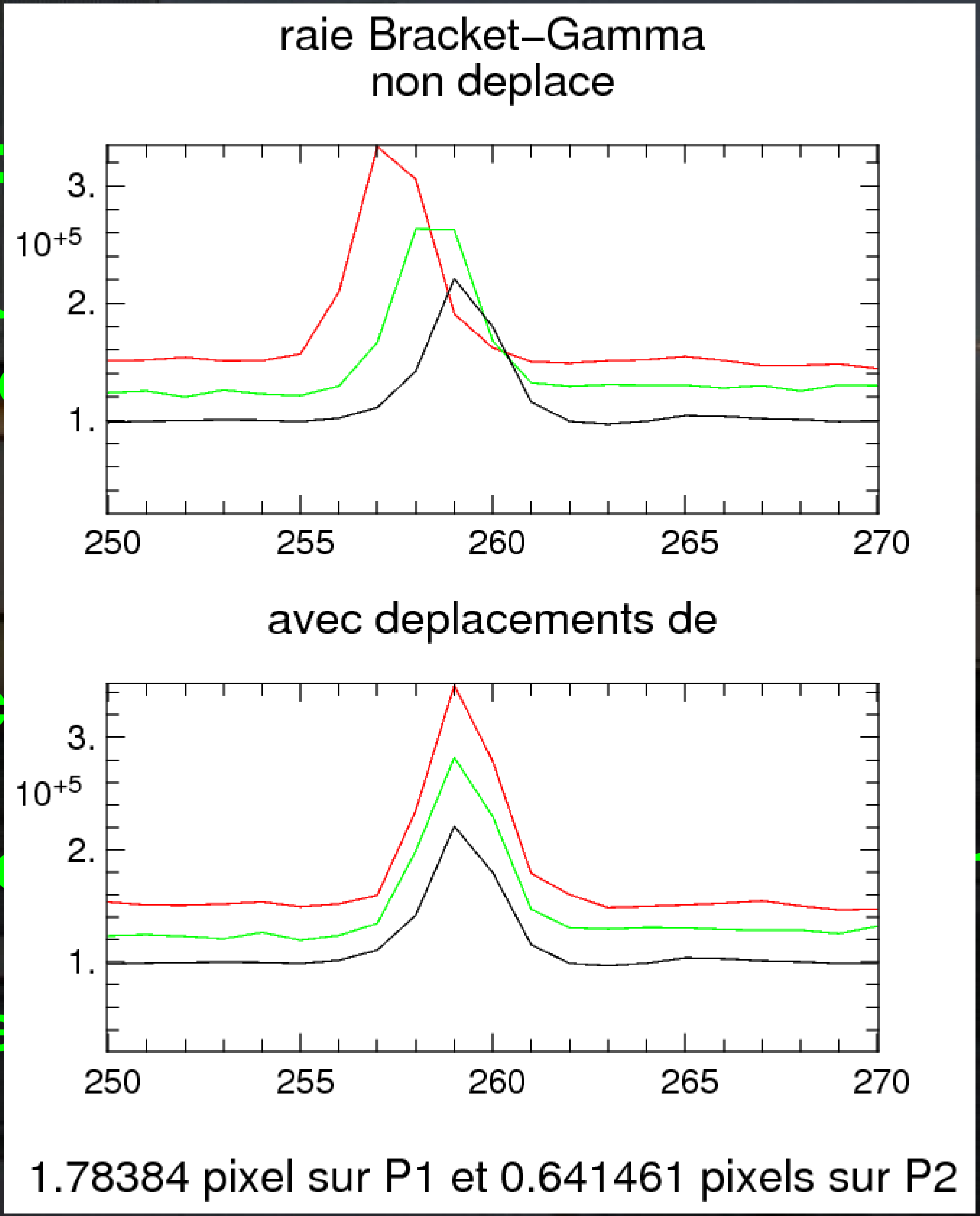

The P2VM algorithm

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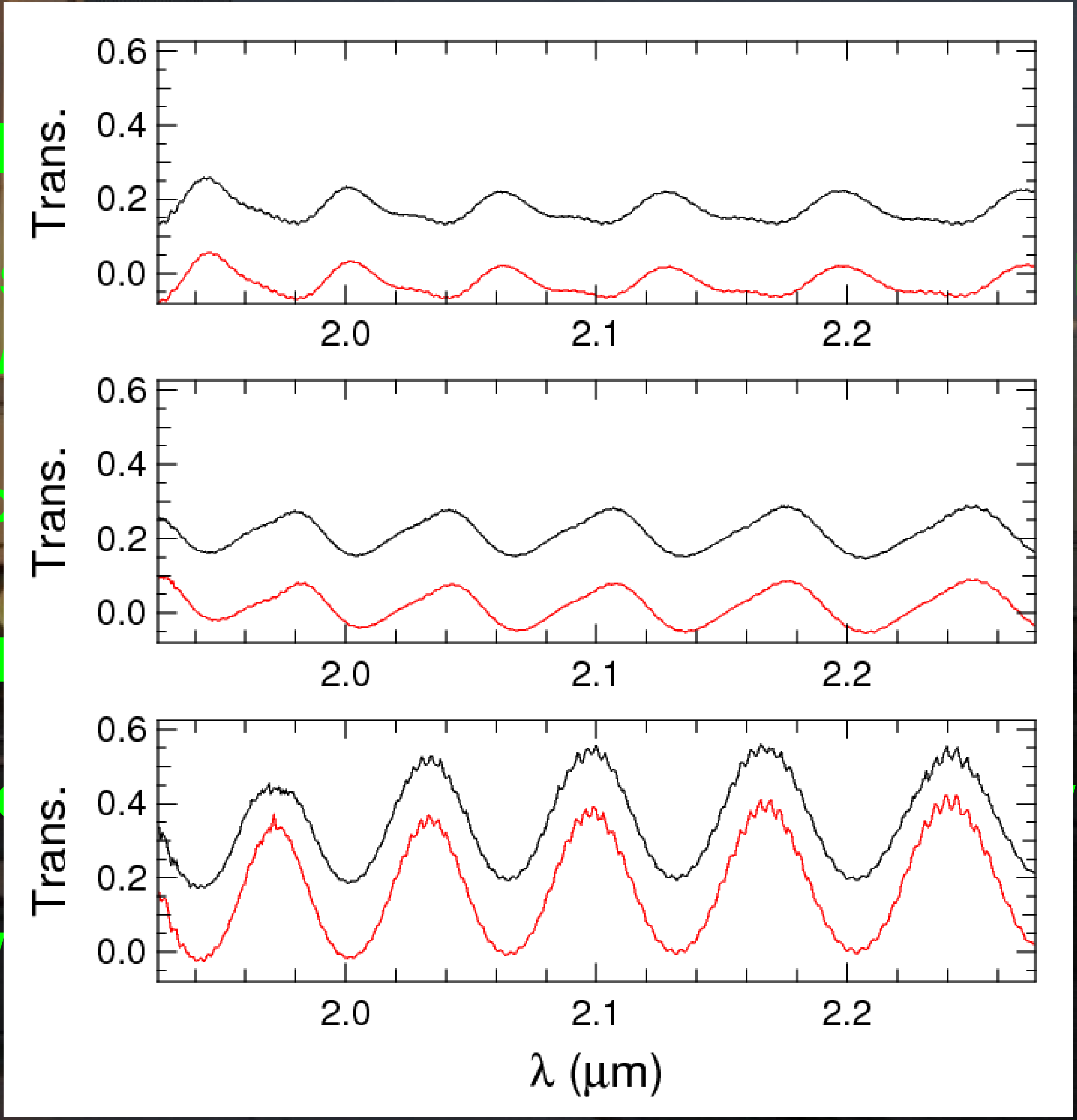
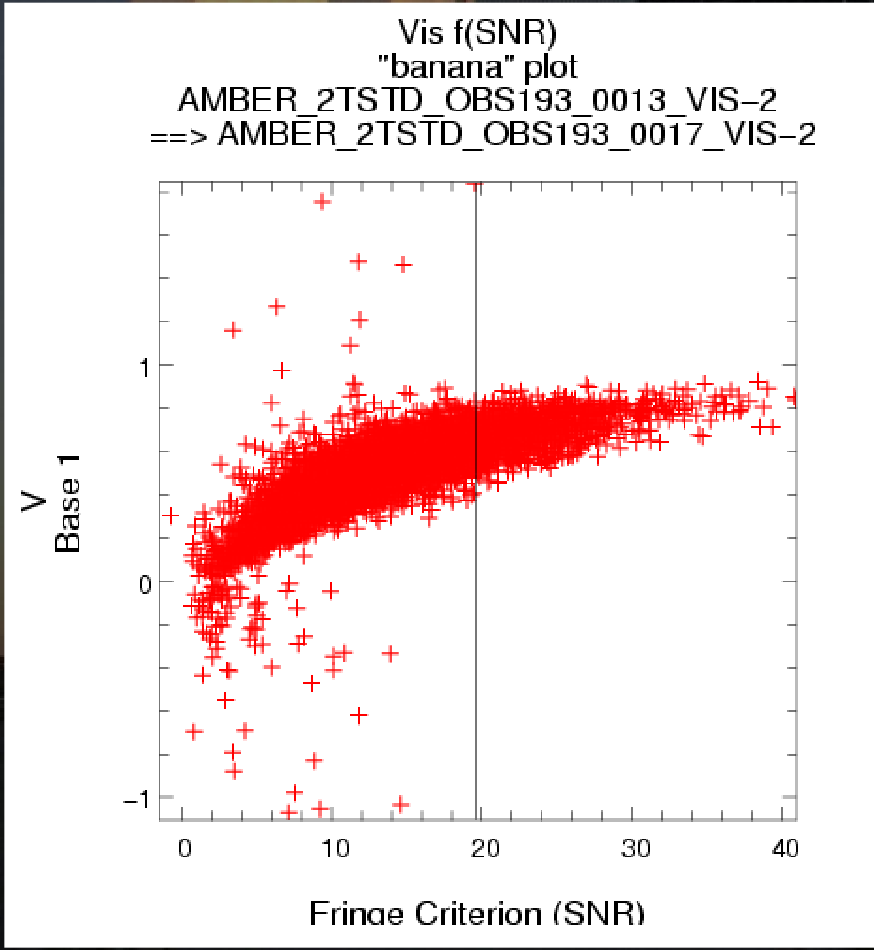


Instrumental contrast on the sky



- Lab visibility : 0.85
- On sky exp. visibility (FSU) : 0.85
- On sky exp. visibility (no FSU) : 0.60

NO FINITO ! :

- Average on-sky UT visibility : 0.20
- Average on-sky AT visibility : 0.60

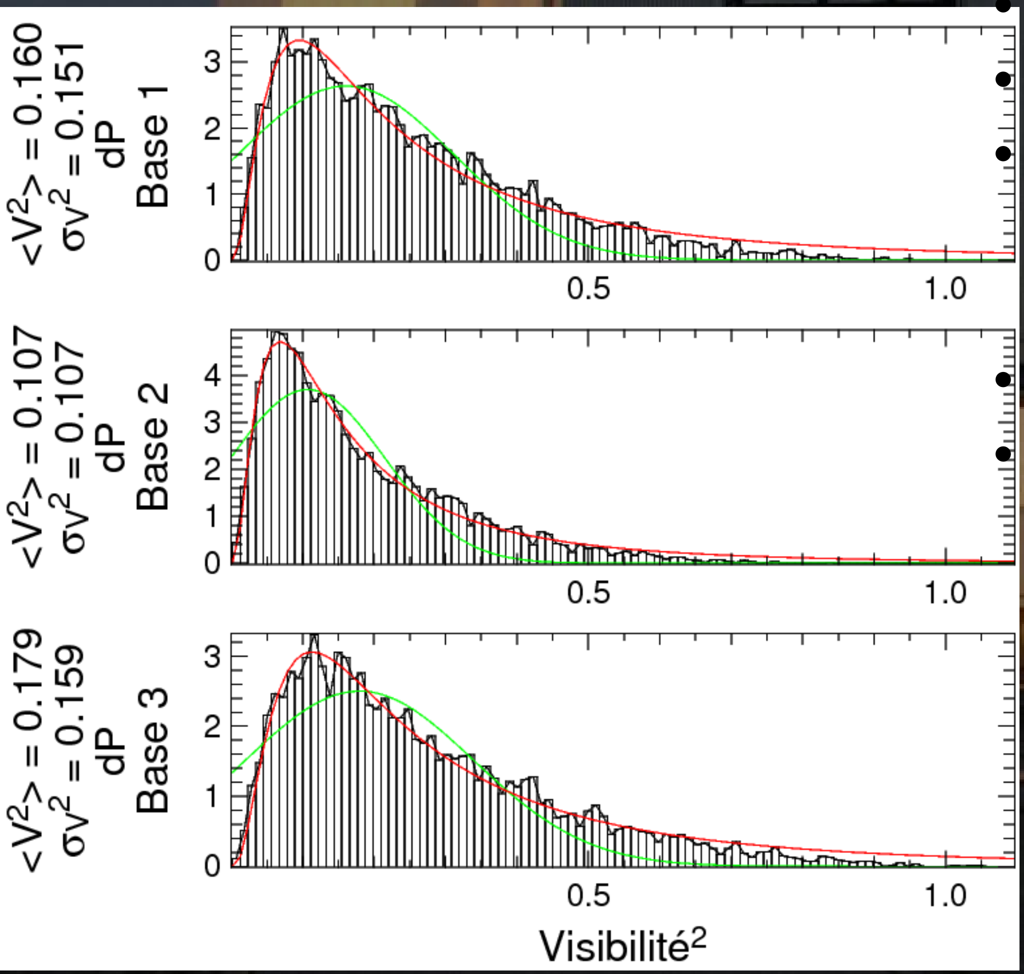
"VLTI / UT vibrations"

OPD modulation between 0.2 & 1µm

Frequency >20Hz

We have a problem

Instrumental contrast on the sky



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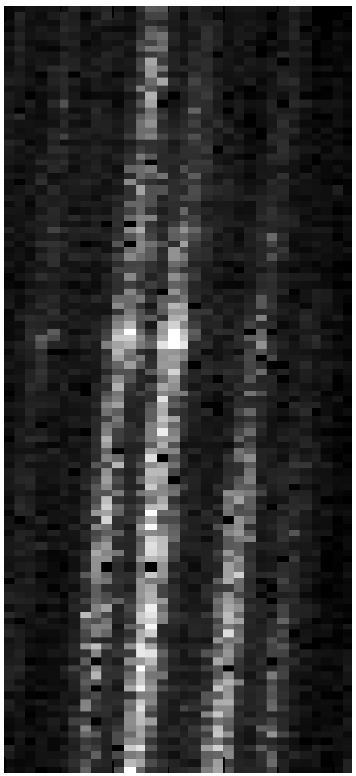
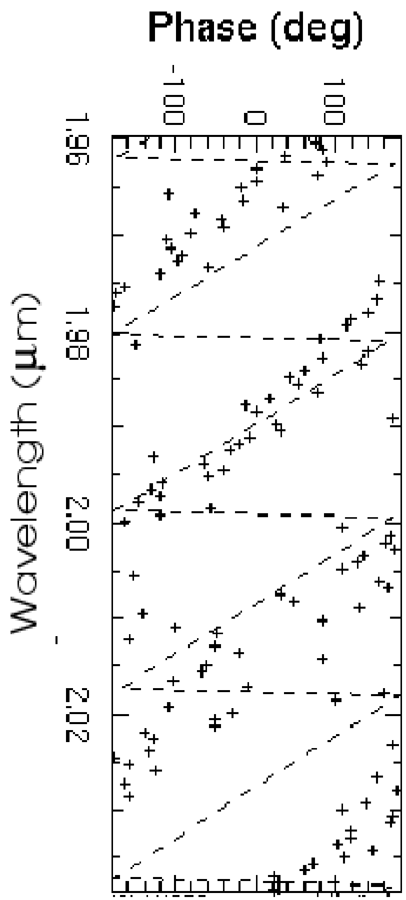
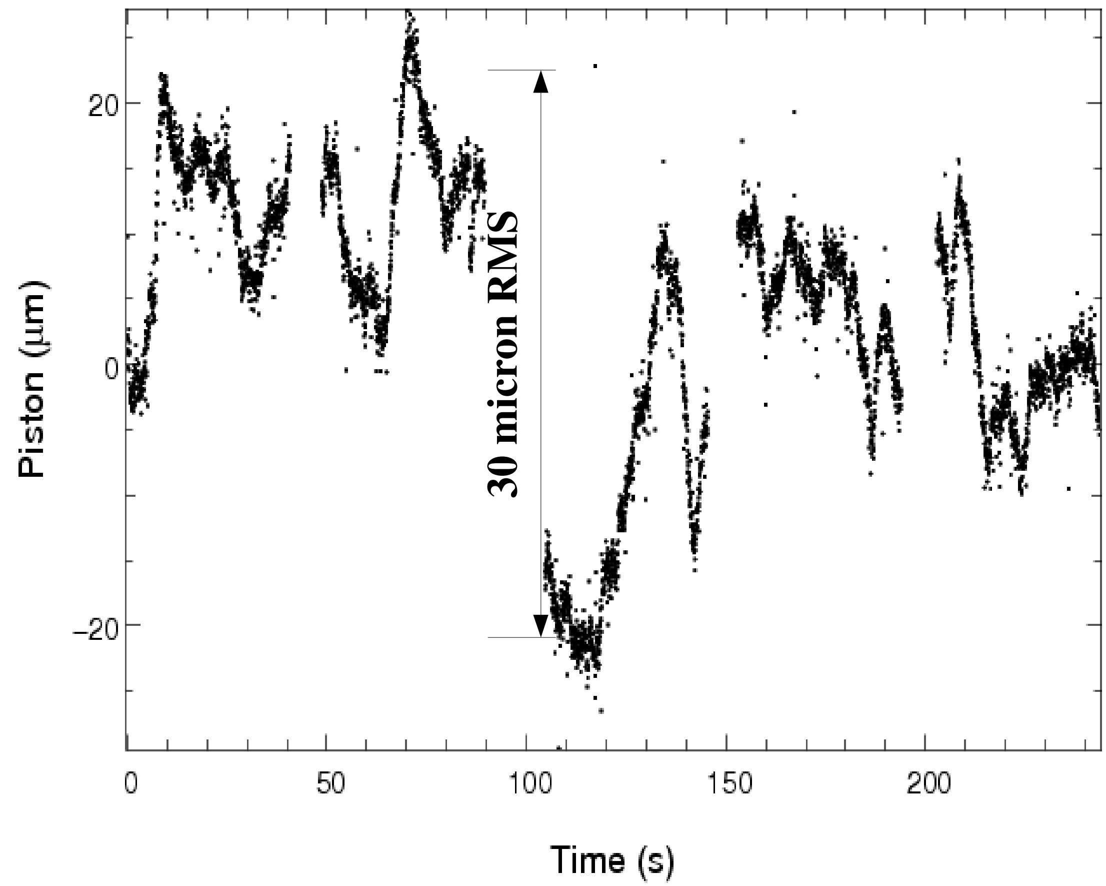
OPD measurements

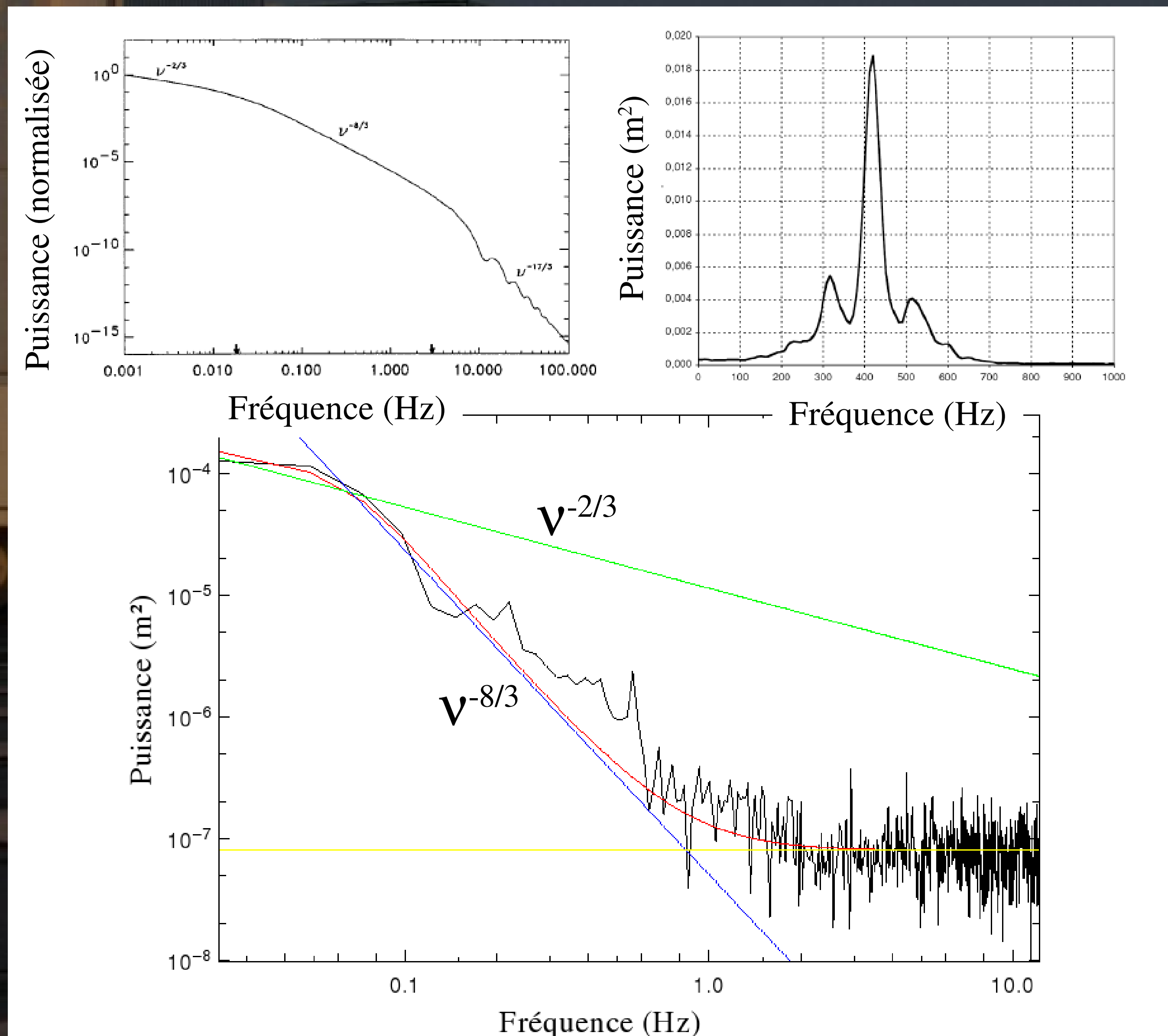






Vibrations and OPD

Conan & co.
1995

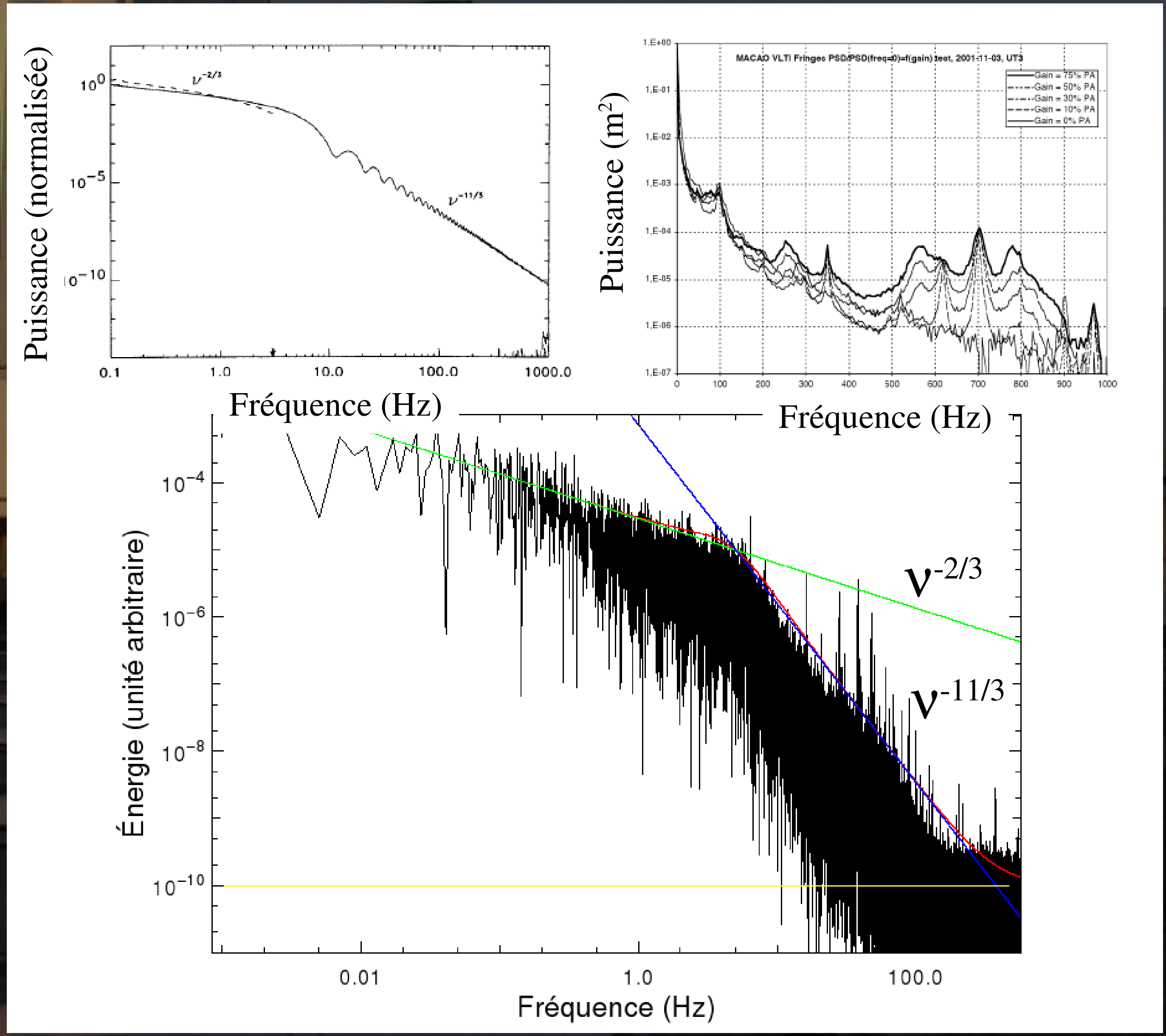


Kervella
2005

Vibrations and flux

Conan & co.
1995

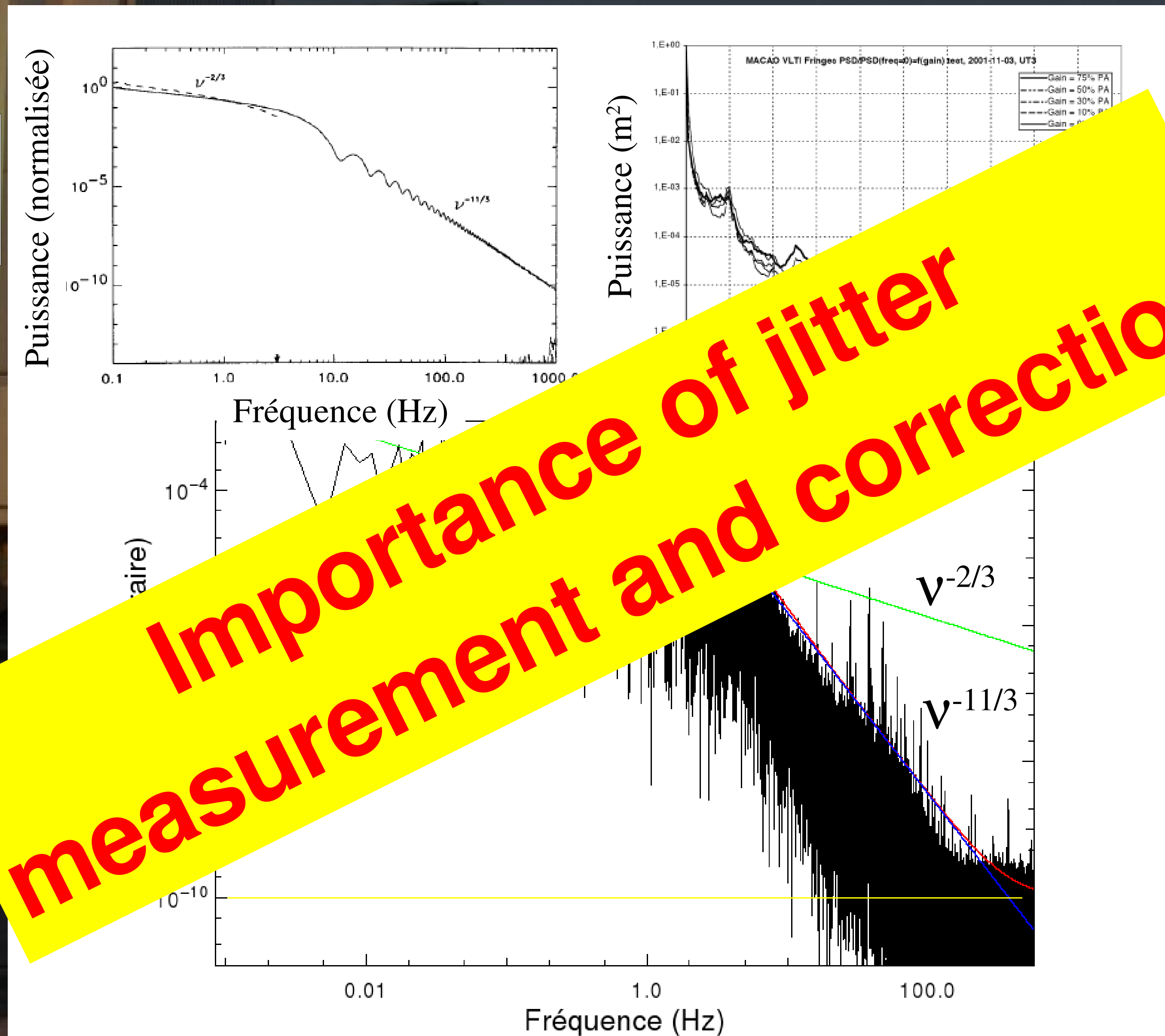
Kervella
2005



Vibrations and flux

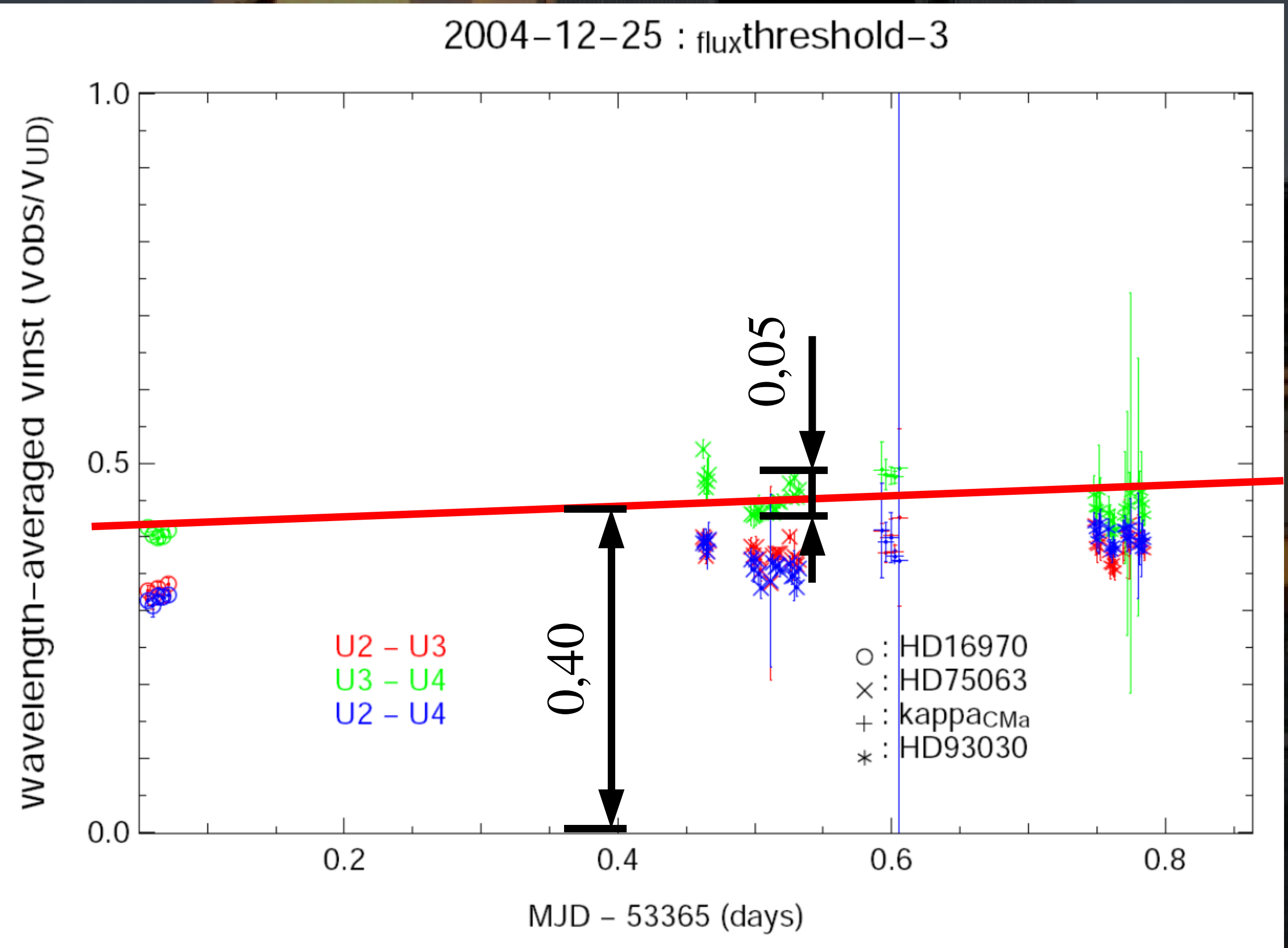
Conan & co.
1995

Kervella
2005

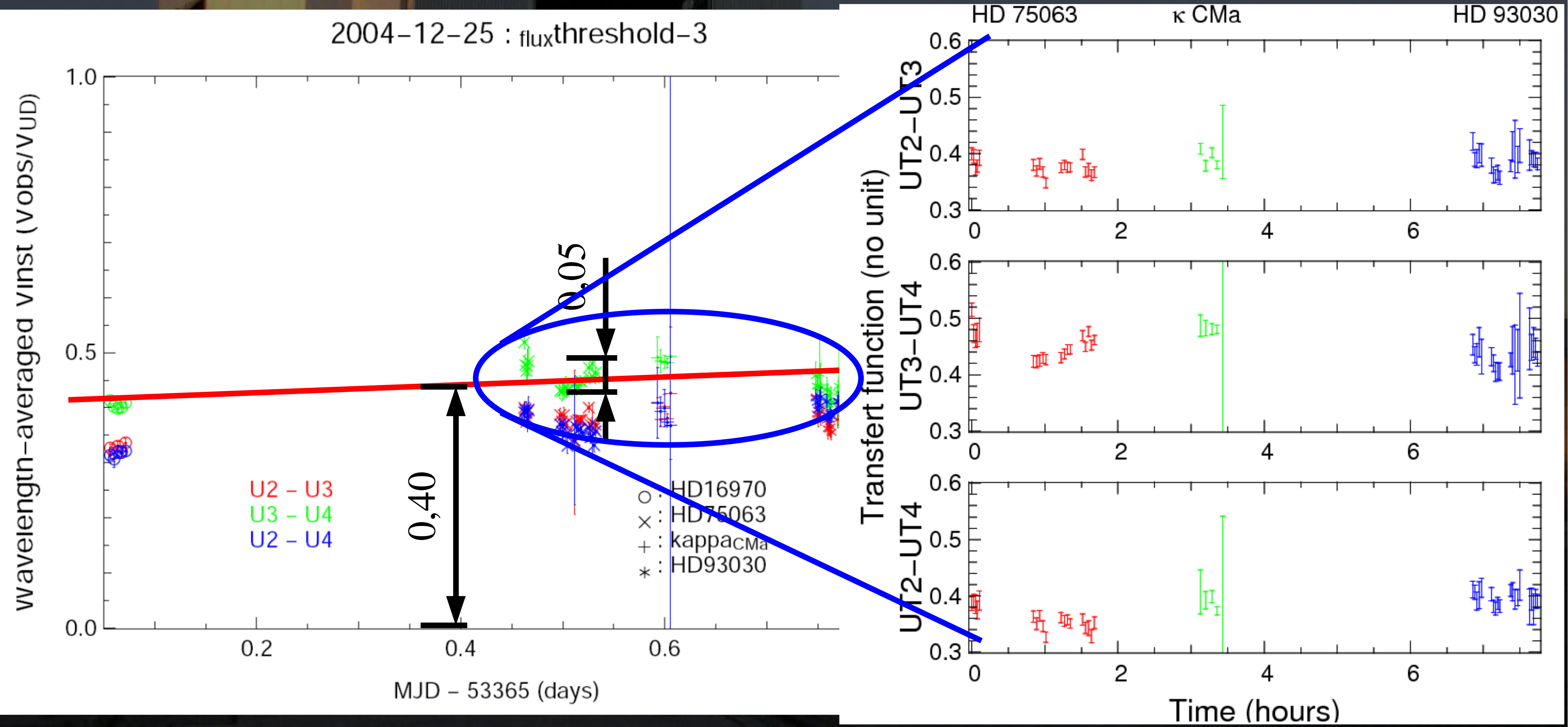


Importance of jitter measurement and correction

“transfert function”



“transfert function”



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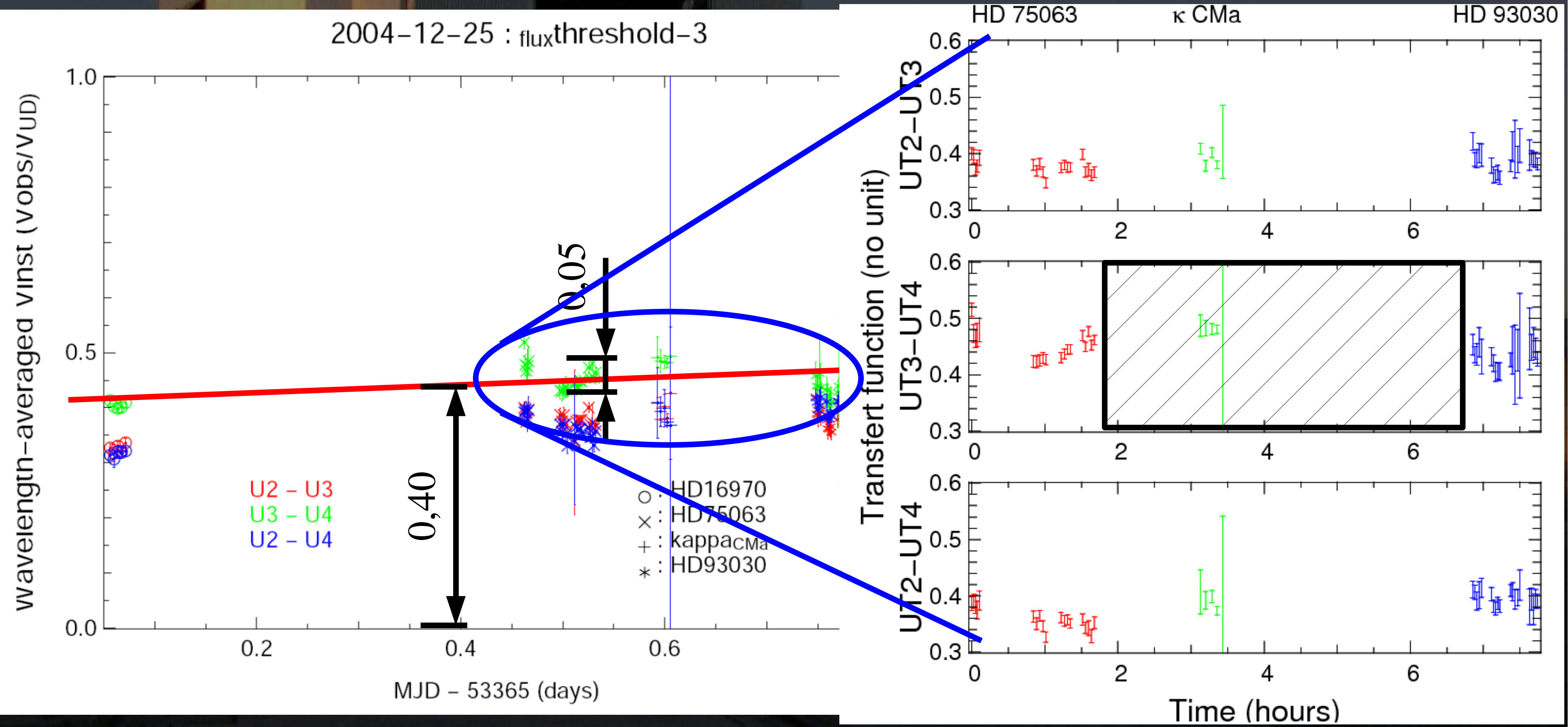

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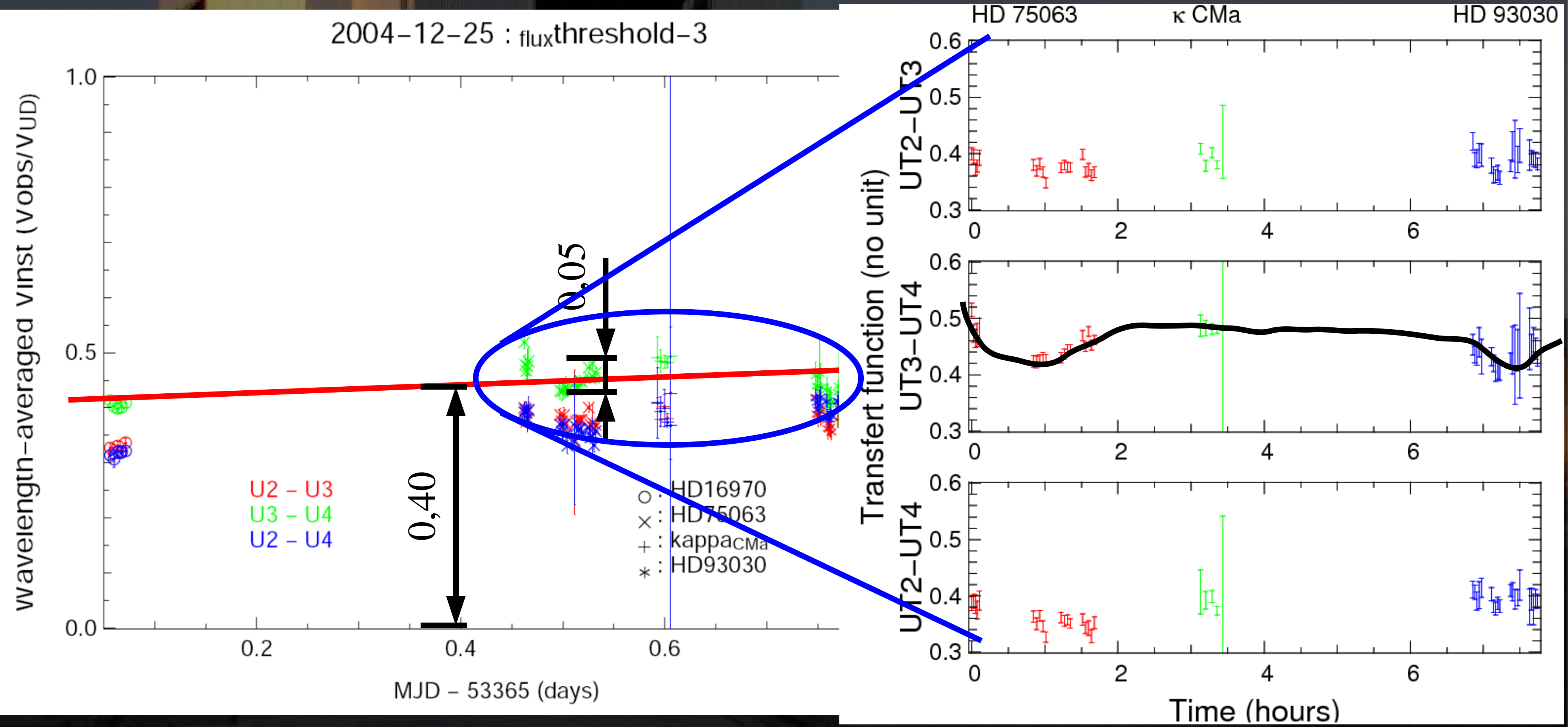
“transfert function”



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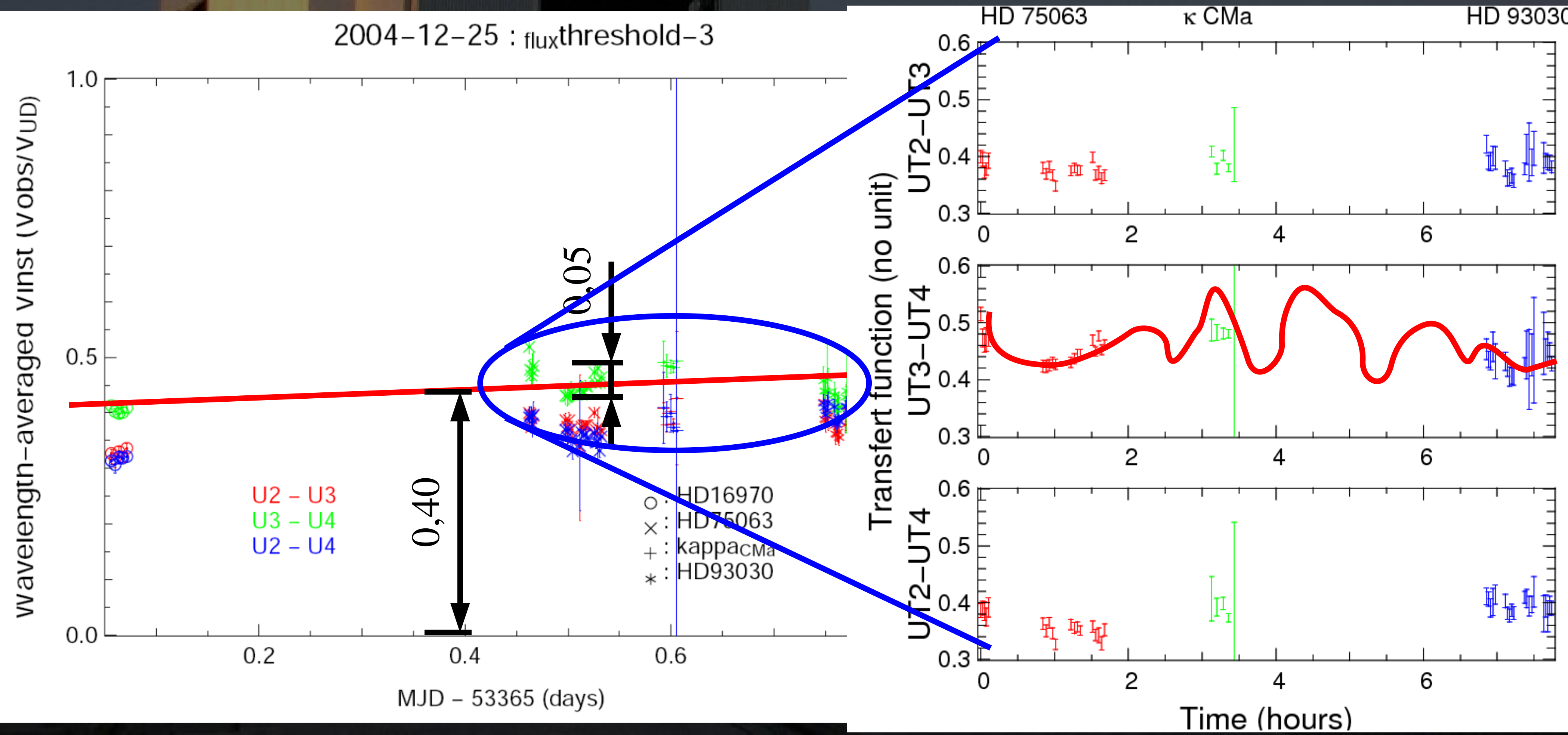

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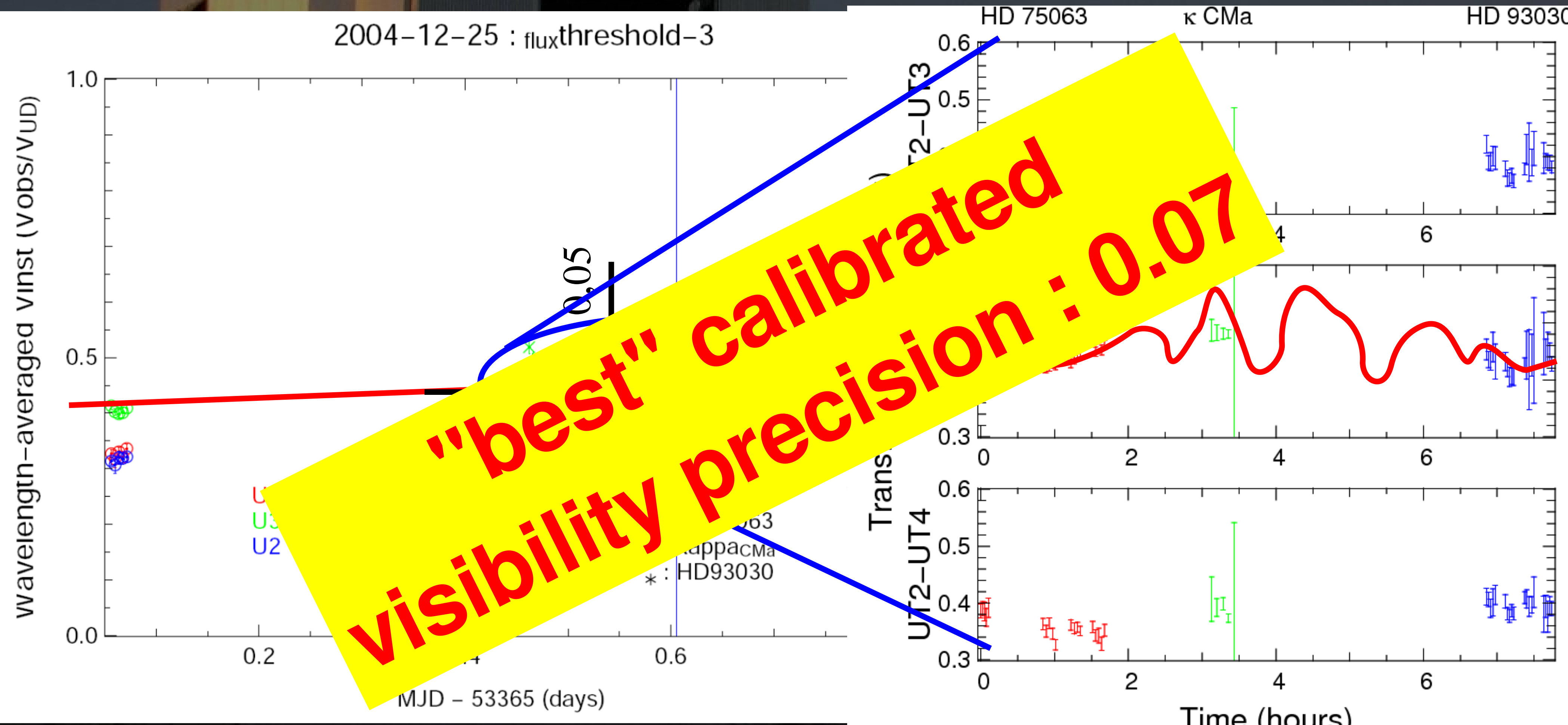
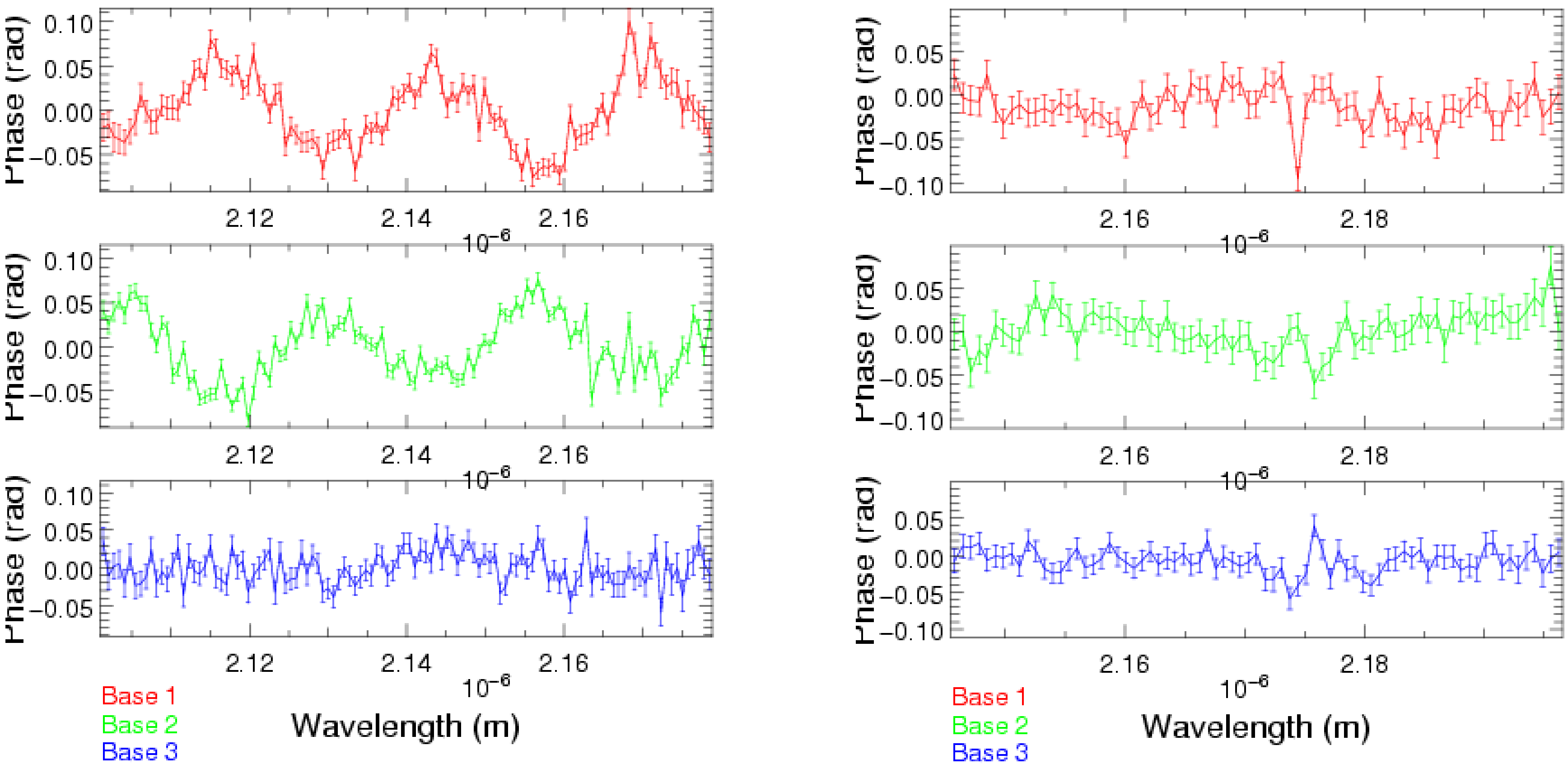


"best" calibrated visibility precision : 0.07

Differential phase bias



“Today's” performances

- Medium spectral resolution (R=1500)
- Bright star (K=3.5)

Typical uncertainties		
	Today	Specs
Visibility	0.05	0.01
Differential visibility	0.01	0.01
Phase closure (rad)	0.05	0.02
Differential phase (rad)	0.01	0.01

“Today's” performances

- Low resolution (R=35)
- Bright star (K=5)

See poster Cruzalèbes et al

Typical uncertainties		
	Today	Specs
Visibility	?	0.01
Differential visibility	?	0.01
Phase closure (rad)	0.01	0.002
Differential phase (rad)	0.001*	0.001

* chromatic dispersion : amplitude ~ from 0.1 rad to 1 rad

What could be improved

- AMBER side :
  - Jitter estimation/correction
  - Detector fringe pattern
  - LR data
  - Closure phase and differential phase high accuracy
- VLTI side
  - VIBRATIONS !
  - FINITO
  - Time delay between measurements

First AMBER/VLTI science

Fabien Malbet[1], Romain Petrov[2], Gerd Weigelt[3], Olivier Chesneau[4], Armando Domiciano de Souza[2], Anthony Meilland[4], Florentin Millour[3], Eric Tatulli[5], and the AMBER consortium

[1] Laboratoire d'Astrophysique de Grenoble, France
[2] Laboratoire Universitaire d'Astrophysique de Nice, France
[3] Max-Planck Institut für Astrophysick, Germany
[4] Observatoire de la Côte d'Azur, Nice, France
[5] Osservatorio Astrofisico di Arcetri, Italy

The AMBER instrument installed at the Very Large Telescope (VLT) combines the beams from three telescopes to produce spectrally dispersed interference fringes with milli-arcsecond angular scales in the near infrared. Three years after installation, first scientific eters give access to many new astrophysical fields that we describe in this paper.

Discs and winds in young stars

The young stellar object MWC 297 is an embedded Herbig Be star exhibiting strong hydrogen emission ject measured by AMBER does not vary between the continuum and the Brα line region, even though the line is strongly detected in the spectrum. This result demonstrates that the line and continuum emission have similar size scales. Assuming that the K-band continuum excess originates in a puffed-up inner rim of

Thank you for your attention

Any question ?