THE MIDI + FSU-A MODE

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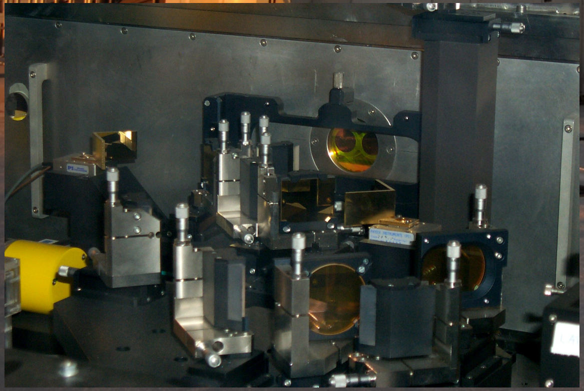
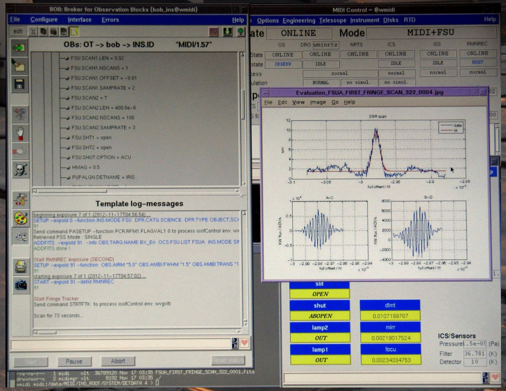
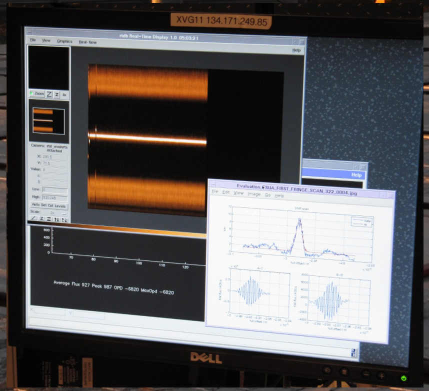
Ramirez, C. Schmid, Th. Henning, ...

*your friendly fringe tracker since April 1, 2013







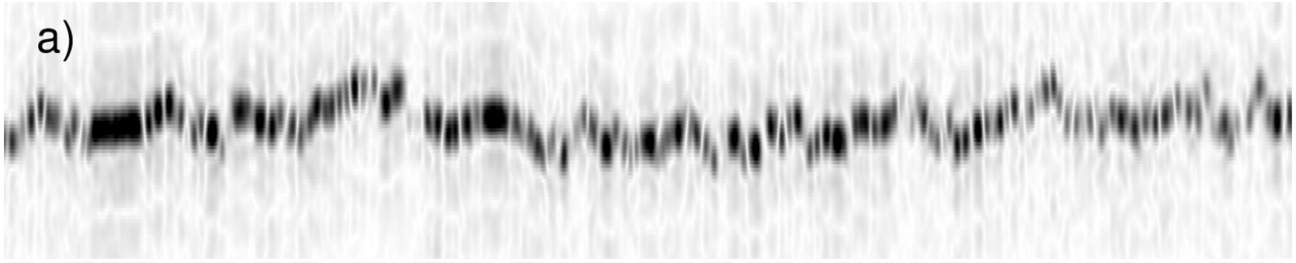
Why?

- Turbulent atmosphere causes piston variations

  ➡ variation of optical path difference (OPD)

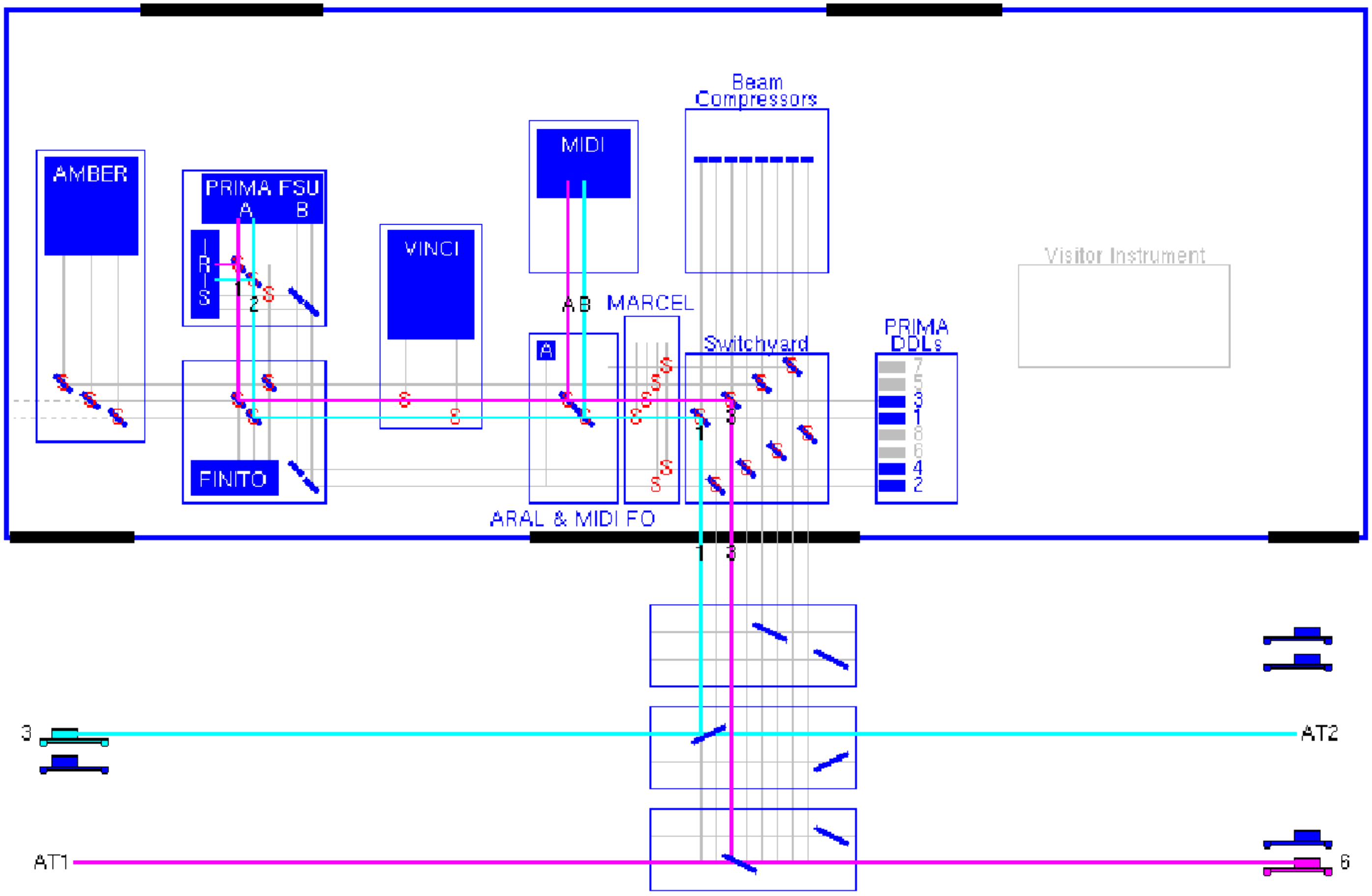
  ➡ degradation of fringe power

  ➡ decreased sensitivity



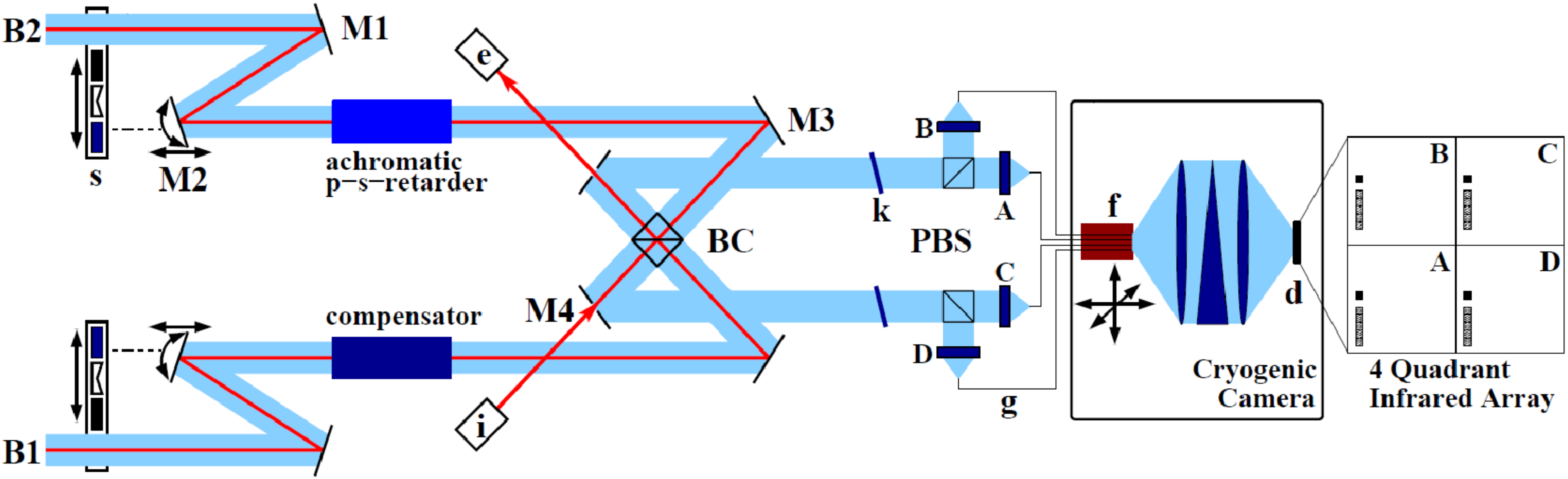
How?

- Fringe tracking on target ("on-axis")
- Offsets sent to the delay line (FSU-A operates at kHz)



PRIMA FSU-A

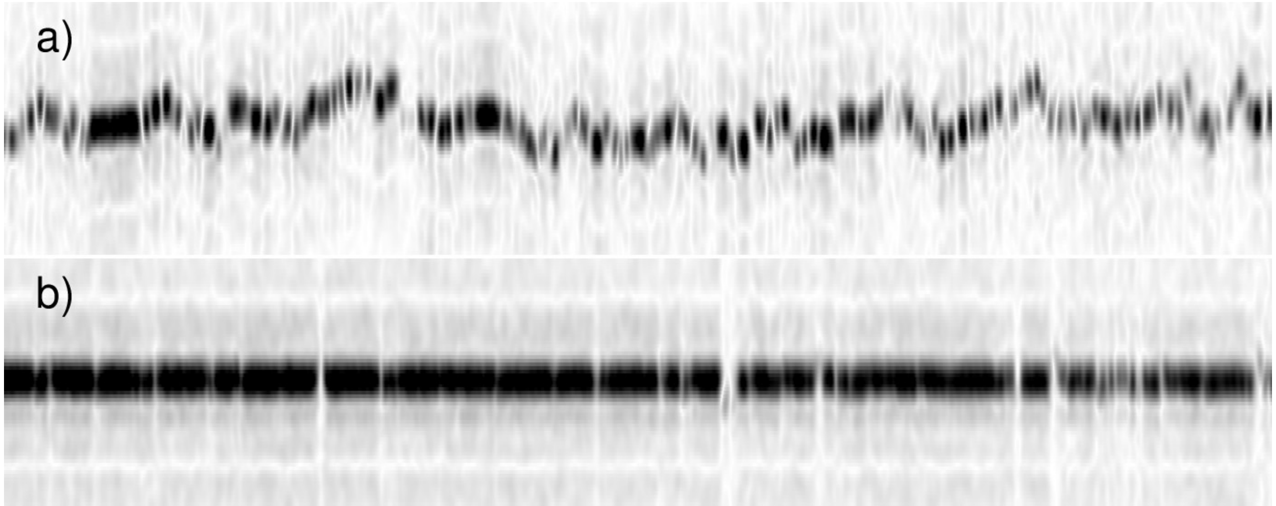
- Four spatially phase shifted beams
- Fringe measured at four points separated by $\lambda/4$
- ABCD principle
- K-band: 2-2.5 μm



Sahlmann et al., 2009

When? A little bit of history...

- 1st light: July 23, 2009 on Altair
- MIDI GD residuals from ~25μm down to ~1μm



- ~10 more nights in 2 years
- January 11, 2012: first test observations with UTs

A little bit of history...

First results using PRIMA FSU as a fringe tracker for MIDI*

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ABSTRACT

We report first results obtained from observations using a PRIMA FSU (Fringe Sensor Unit) as a fringe tracker for MIDI on the VLTI when operating with the 1.8-m ATs. Interferometric observations require the correction of the disturbance in the optical path induced by atmospheric turbulence ("piston"). The PRIMA FSU is able to compensate for such disturbances in real-time which makes it a suitable facility to stabilize the fringe signal for other VLTI instruments, like AMBER, MIDI or later MATISSE. Currently, the atmospheric coherence time in the N band (8 to 13 μm) observed by MIDI, as well as the thermal background in this band, require a minimum target flux of 20 Jy and a correlated flux of 10 Jy (in PRISM/HIGH_SENSE mode and using the ATs under standard conditions) to allow self-fringe-tracking and data reduction. However, we show that if the fringes are stabilized by the FSU, coherent integration allows a reliable data reduction even for the observation of faint targets (F_{corr} <10 Jy) with MIDI at standard detector exposure times. We were able to measure the correlated flux of a 0.5 Jy source, which pushes the current limits of MIDI down to regions where numerous new targets become accessible on ATs. For faint object observations we will discuss the usage of VISIR photometry for calibration purposes. The observational tests done so far and the obtained results represent a first step towards Phase Referenced Imaging with the VLTI in the mid-infrared.

Keywords: Interferometry, VLTI, MIDI, PRIMA, fringe tracking, high angular resolution, faint object observation

1. INTRODUCTION

MIDI (the mid-infrared interferometric instrument) on the Very Large Telescope interferometer (VLTI), is a two beam Michelson type interferometer producing dispersed fringes in the N band over a wavelength range from 8 to 13 μm.[1] A prism providing a resolution of R=30 and a grism providing a resolution of R=230 at λ=10.6 μm are the available dispersive elements. MIDI has two observation modes depending on two beam splitters in front of the beam combiner which reflect 30% of the incoming light into photometric beams which allows to measure the interferometric signal simultaneously to the photometric flux. This mode is called "science-photometry" (SCI_PHOT). If the beam splitters are not inserted, all

Müller et al., 2010, SPIE

A little bit of history...

EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

OBSERVING PROGRAMMES OFFICE • Karl-Schwarzschild-Straße 2 • D-85748 Garching bei München • e-mail: opo@eso.org • Tel.: +49-89-32 00 64 73

APPLICATION FOR OBSERVING TIME — PERIOD: **87A**

MIDI-consortium GTO

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of CoIs and the agreement to act according to the ESO policy and regulations, should observing time be granted

1. Title — Category: **C–7**

Optimizing the MIDI differential phase precision as a step towards direct planet detection.

2. Abstract / Total Time Requested

Total Amount of Time: 3 nights VM, 0 hours SM

We propose to improve the VLTI mid-infrared differential phase ($d\phi$) precision by using external fringe tracking. Recent on-sky experiments with MIDI and AMBER showed that the typically achieved $d\phi$ precision is currently a factor of ten above the level required for direct, interferometric exo-planet detection ($\sim$ 1 mrad). We plan to exploit new fringe tracking capabilities at the VLTI, the PRIMA-FSU, to reach the mrad limit for the first time in an observation. This new technical setup allows to explore a previously unaccessible realm of high-precision MIDI measurements. We intend to feedback our results to ESO to facilitate full commissioning of such an observing mode, and to predict gains of the future PRIMA faint object (= off-axis) operation. The results are also important for the 2nd generation instrument MATISSE, since we will probe the achievable $d\phi$-precision at MIR wavelengths at the VLTI with external NIR fringe tracking, a foreseen mode of operation of MATISSE.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	87	MIDI	3n	sep	n	n	THN	v	

4. Number of nights/hours — Telescope(s) — Amount of time

a) already awarded to this project:

b) still required to complete this project:

5. Special remarks:

We offer to use GTO time to accumulate a science verification data set for MIDI+FSU(on-axis) to estimate its science potential. P. Haguenauer encouraged this submission to enable its feasibility assessment by ESO.

6. Principal Investigator: J.-U. Pott, jpott@mpia.de, D, Max Planck Institut fuer Astronomie

6a. Co-investigators:

A.	Müller	ESO Headquarters Garching,ESO
Ch.	Leinert	Max Planck Institut fuer Astronomie,D
Th.	Henning	Max Planck Institut fuer Astronomie,D
B.	Lopez	Observatoire de la Cote d'Azur Nice,Siege Social,F

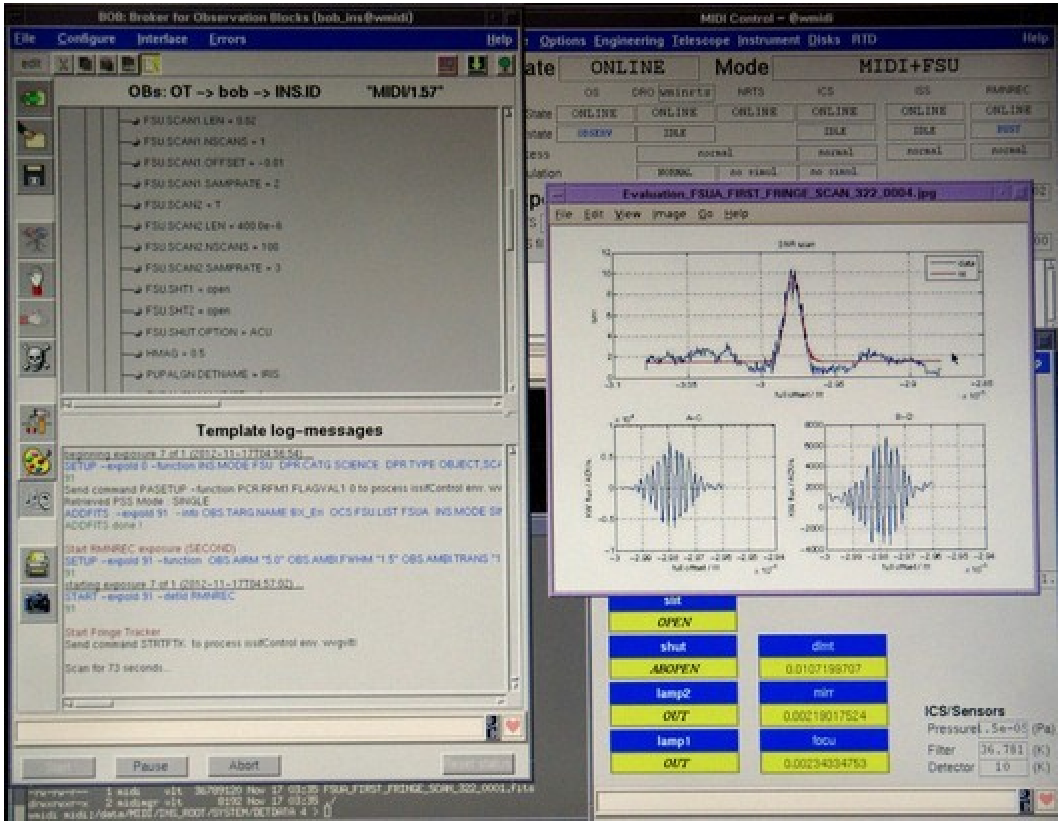
Following CoIs moved to the end of the document ...

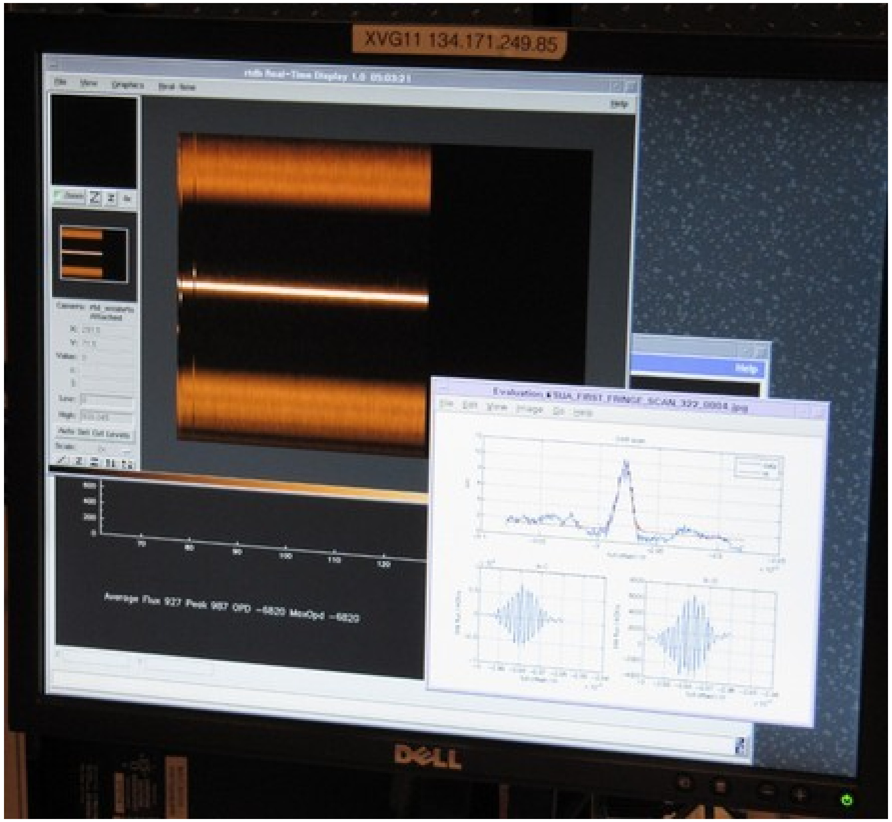
PI: J.U. Pott

IRIS “last” light

Commissioning / “Paranalization”

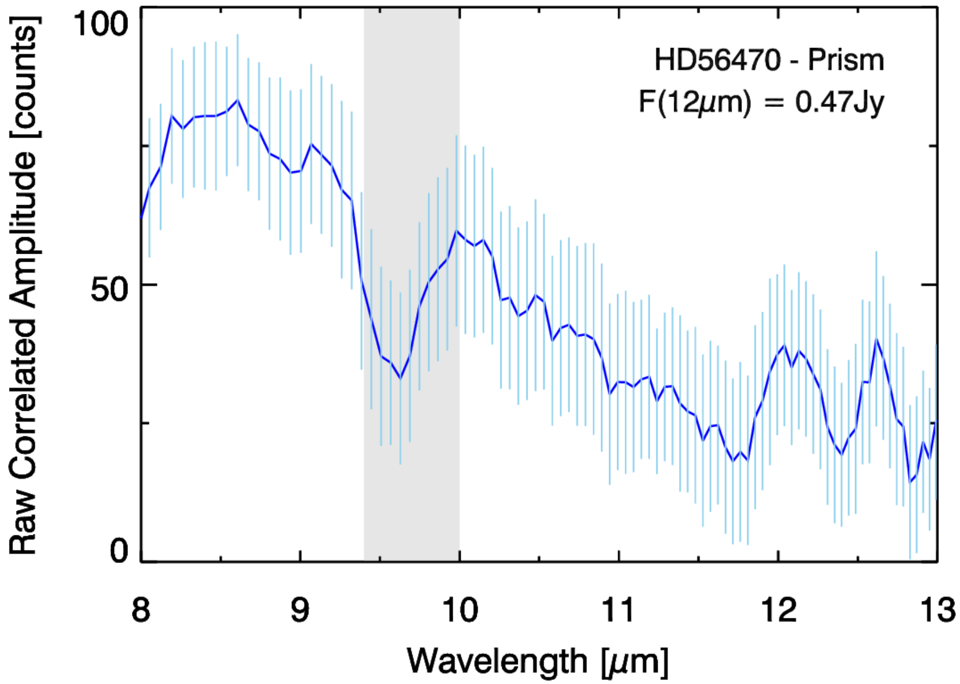
- November 11-17, 2012
- Offered to the community with start of ESO P91 (April 1, 2013)

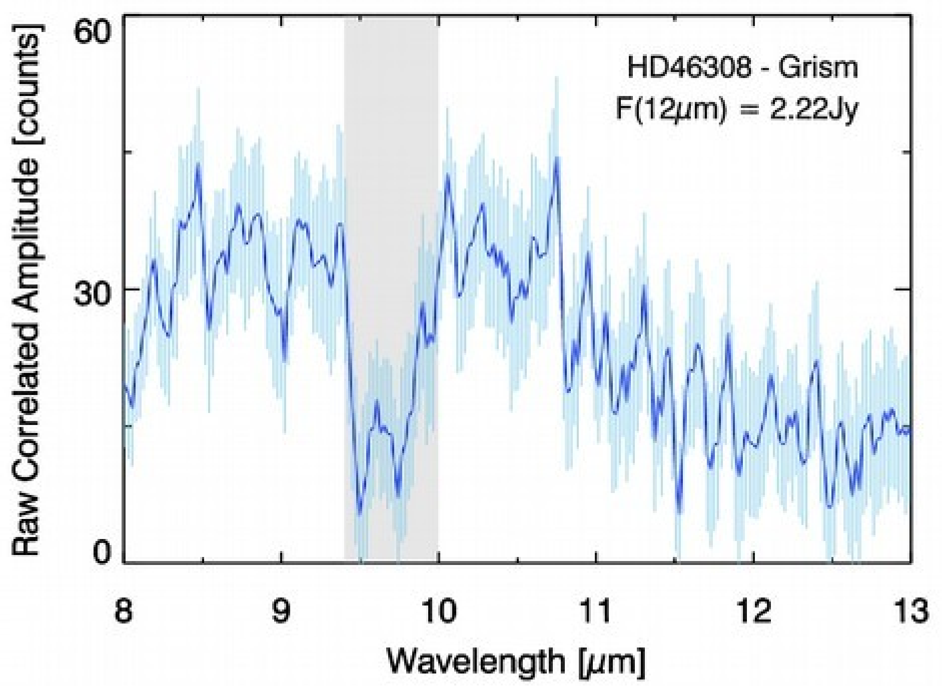




Commissioning / “Paranalization”

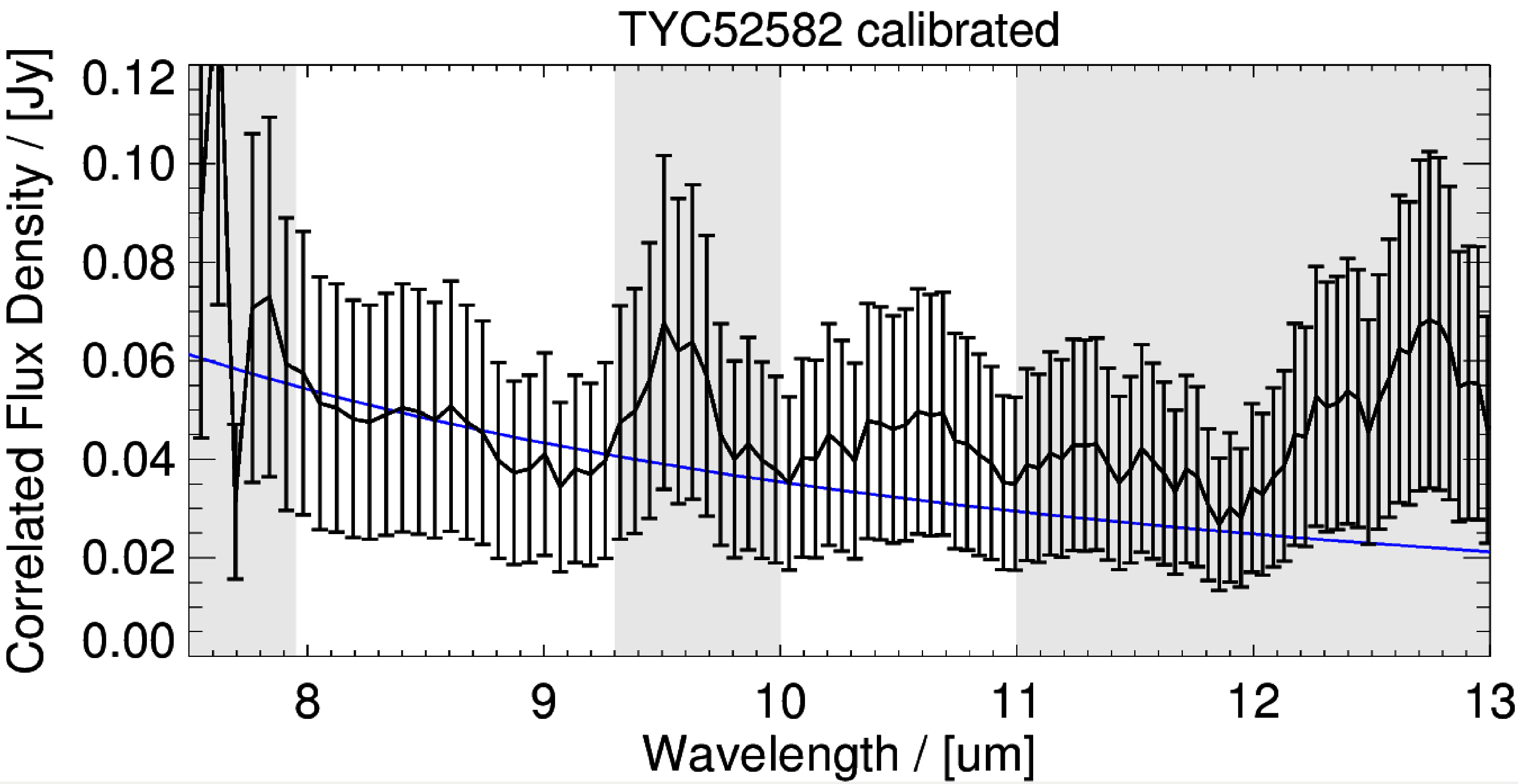
Highlights – faint N-band, ATs





Müller et al., 2010
Müller, Pott et al., 2014, subm.

Highlights – faint N-band, UTs

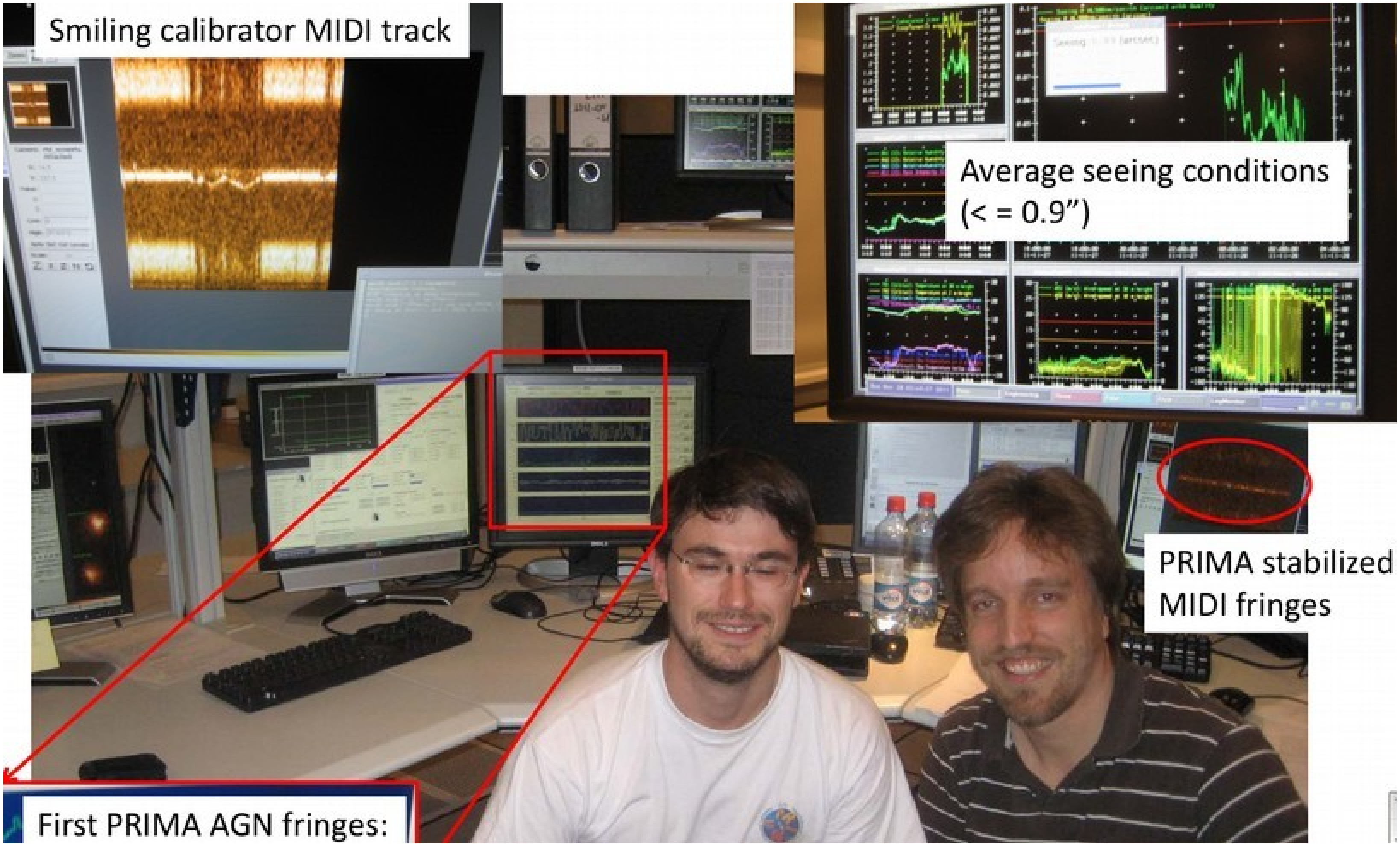


Müller, Pott et al., 2014, subm.

Highlights – faint K-band, 9.5mag

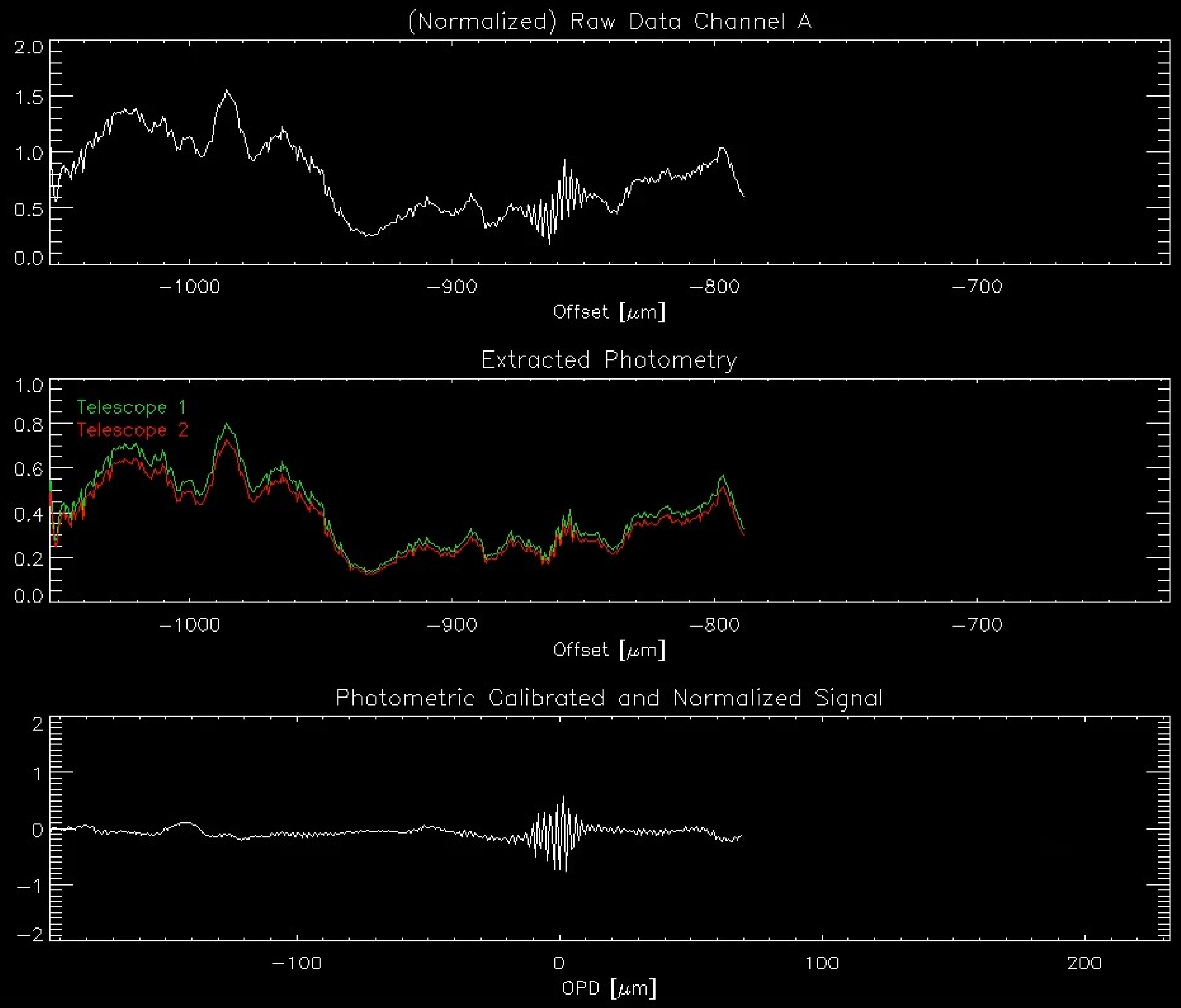
- First FSU-A fringe track on AGN NGC1068

  November 27, 2011



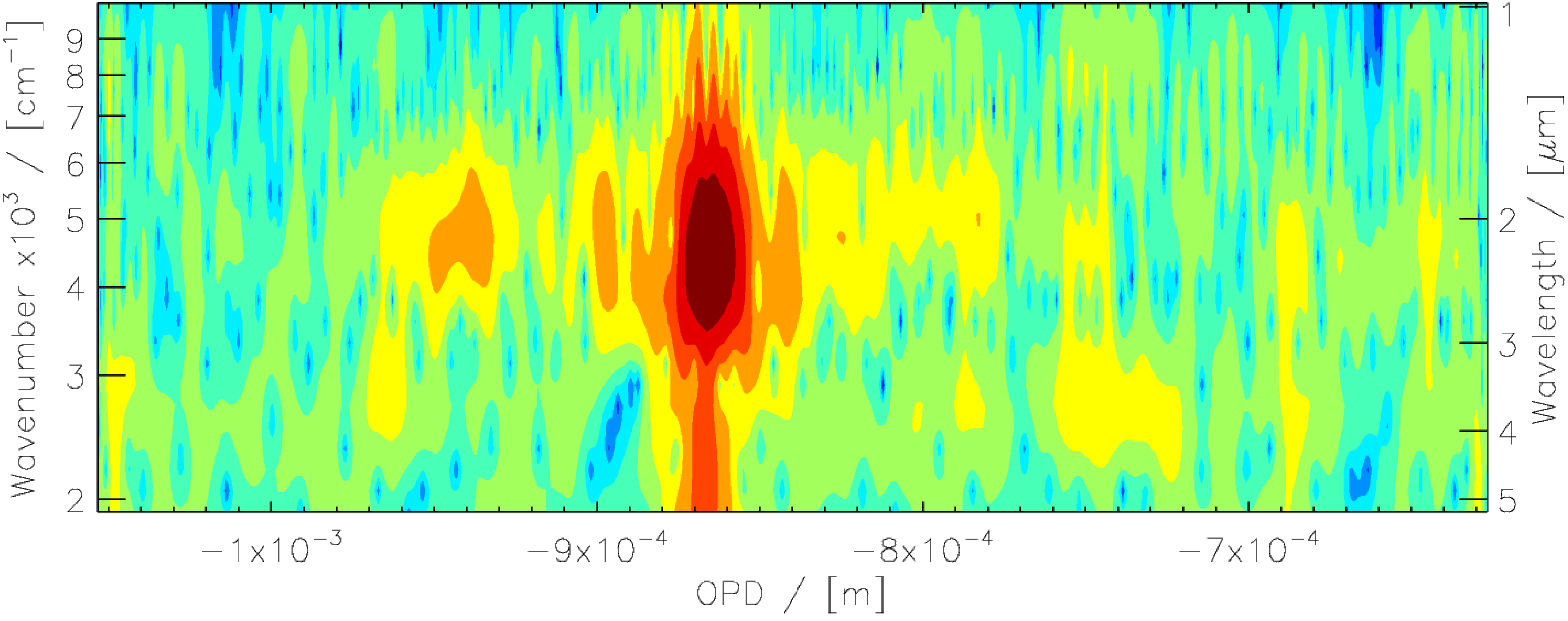
K-band Visibilities

- It is possible!
- Fringe scanning with FSU-A
- Before N-band observation
- 5min overhead



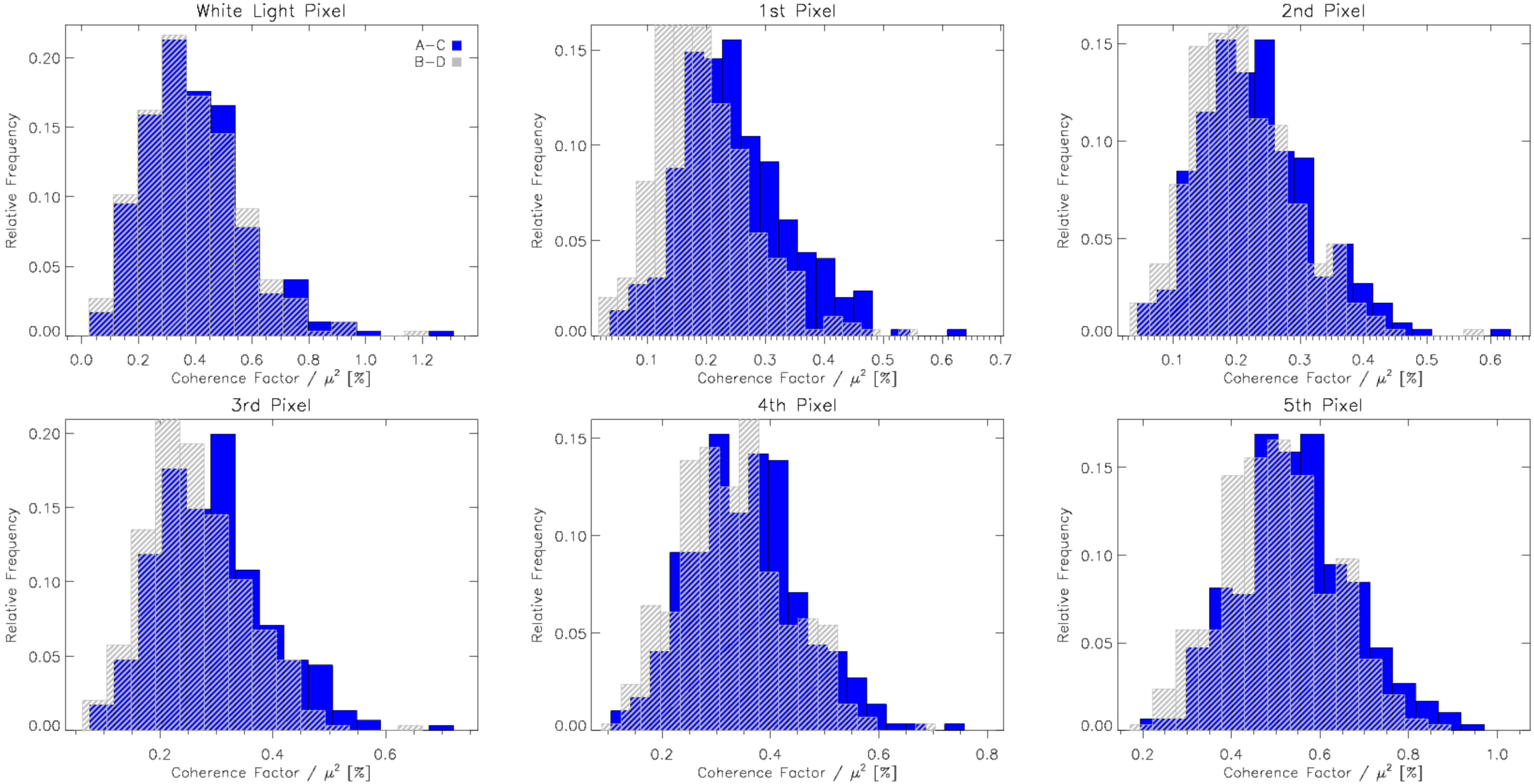
(Normalized) Raw Data Channel A
2.0
1.5
1.0
0.5
0.0
−1000
−900
−800
−700
Offset [μm]
Extracted Photometry
1.0
0.8
0.6
0.4
0.2
0.0
Telescope 1
Telescope 2
−1000
−900
−800
−700
Offset [μm]
Photometric Calibrated and Normalized Signal
2
1
0
−1
−2
−100
0
100
200
OPD [μm]

K-band Visibilities
Wavelet Analysis



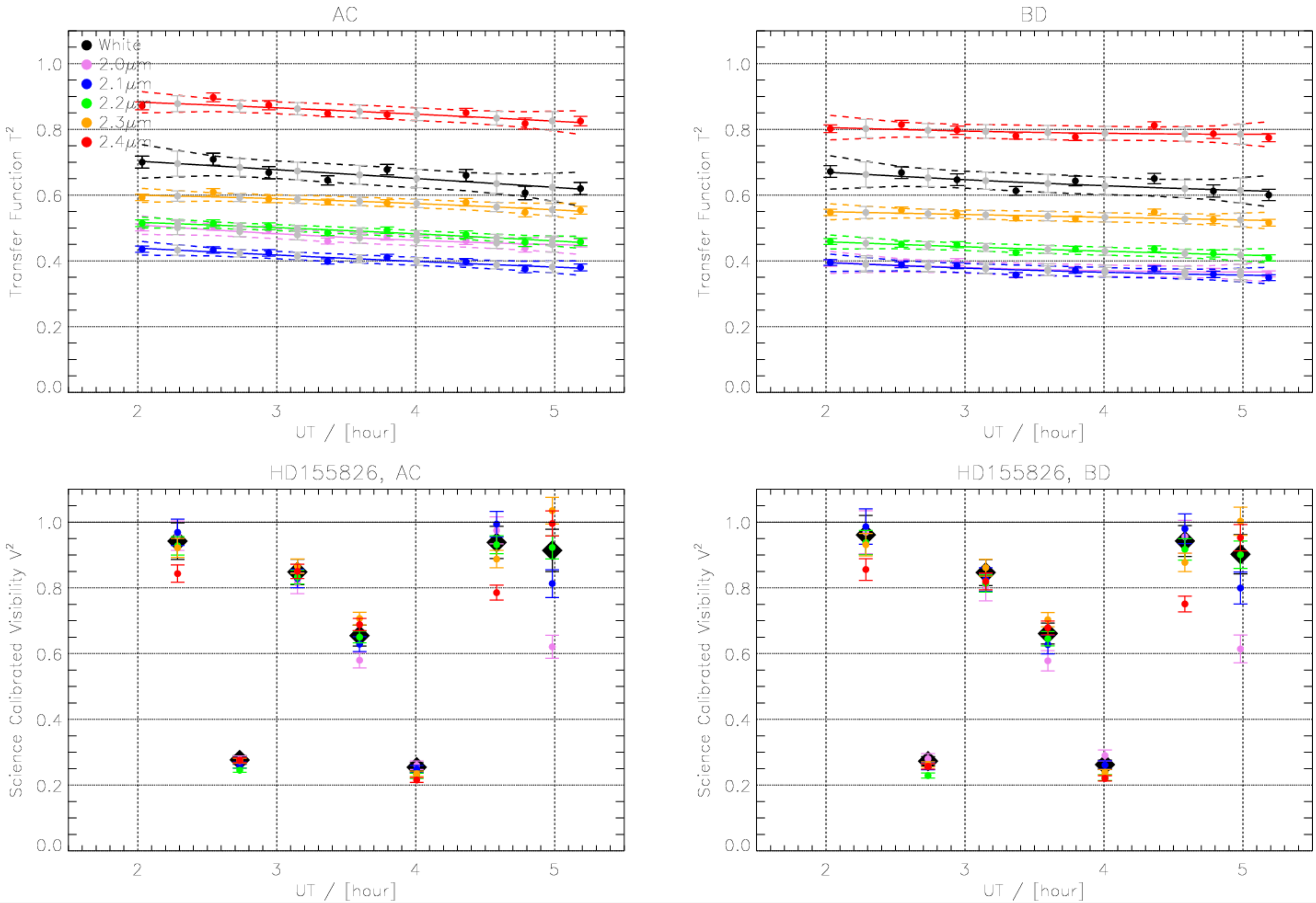
Müller, Pott et al., 2014, subm.

K-band Visibilities Coherence Factor



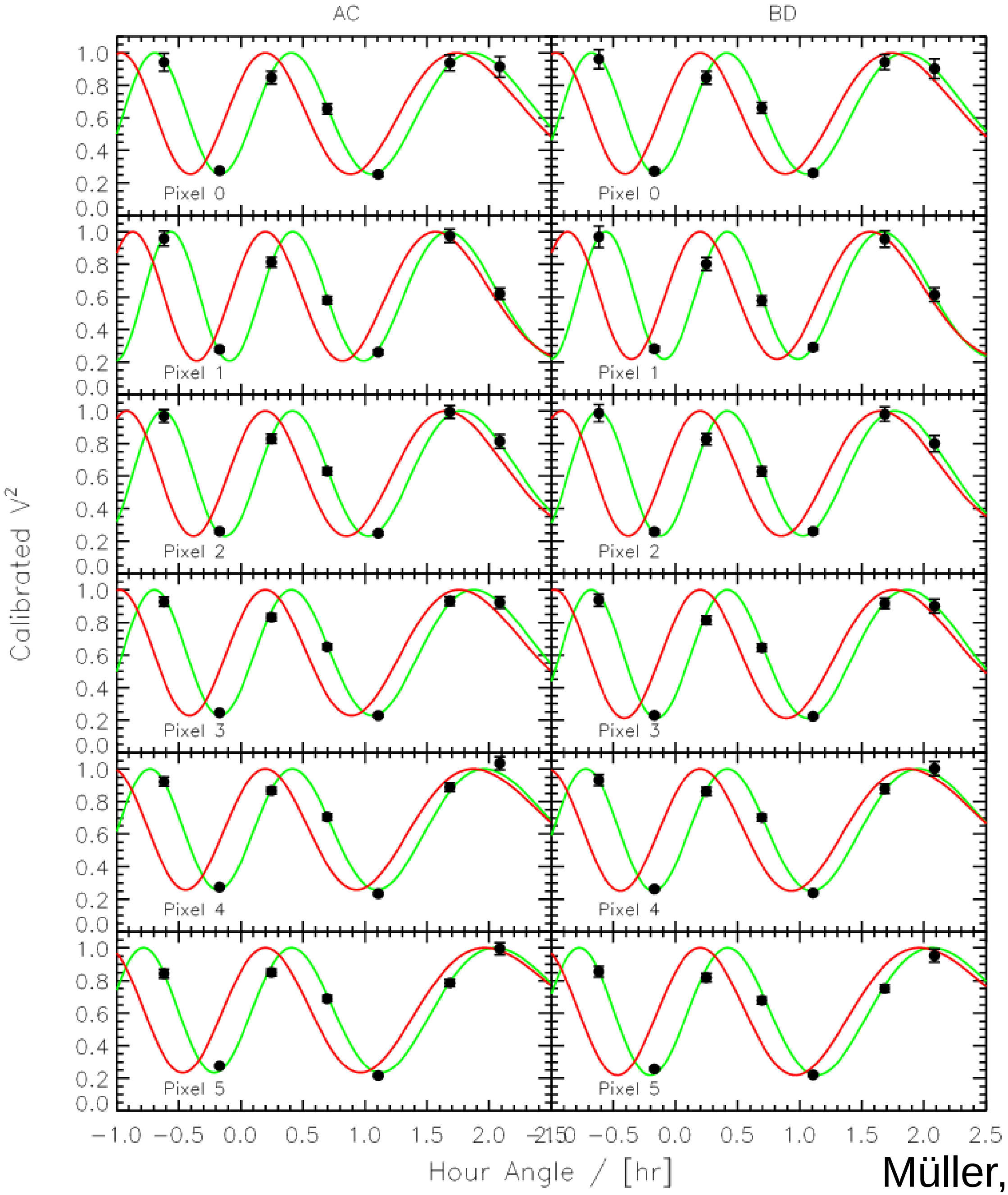
Müller, Pott et al., 2014, subm.

K-band Visibilities



Müller, Pott et al., 2014, subm.

K-band Visibilities

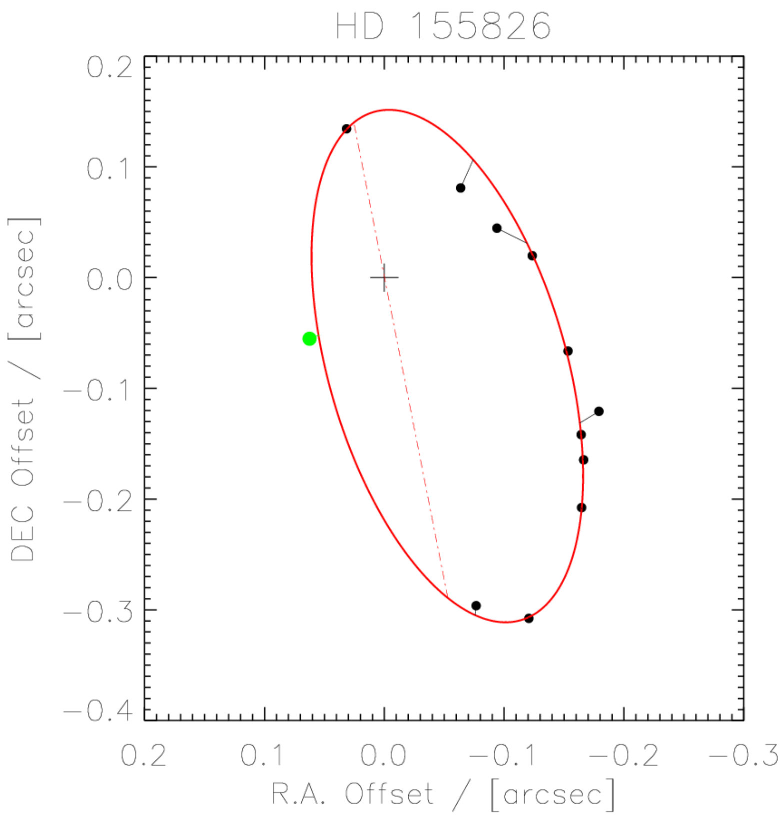


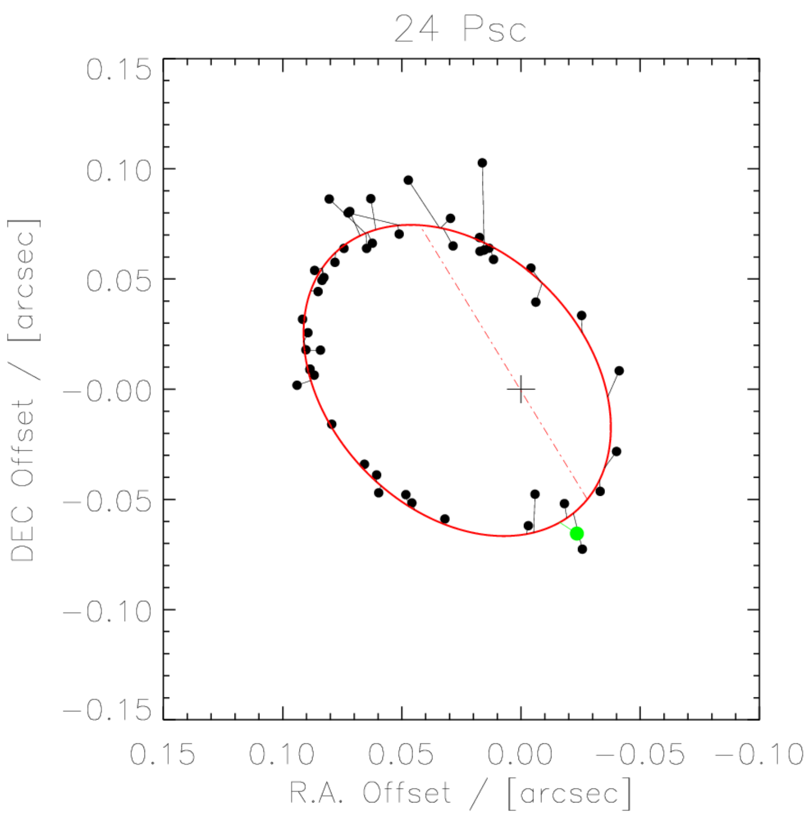
Müller, Pott et al., 2014, subm.

K-band Visibilities

Published orbits by Mason et al., 2010

a=250mas, P=14.2yr a=83mas, P=22.8yr

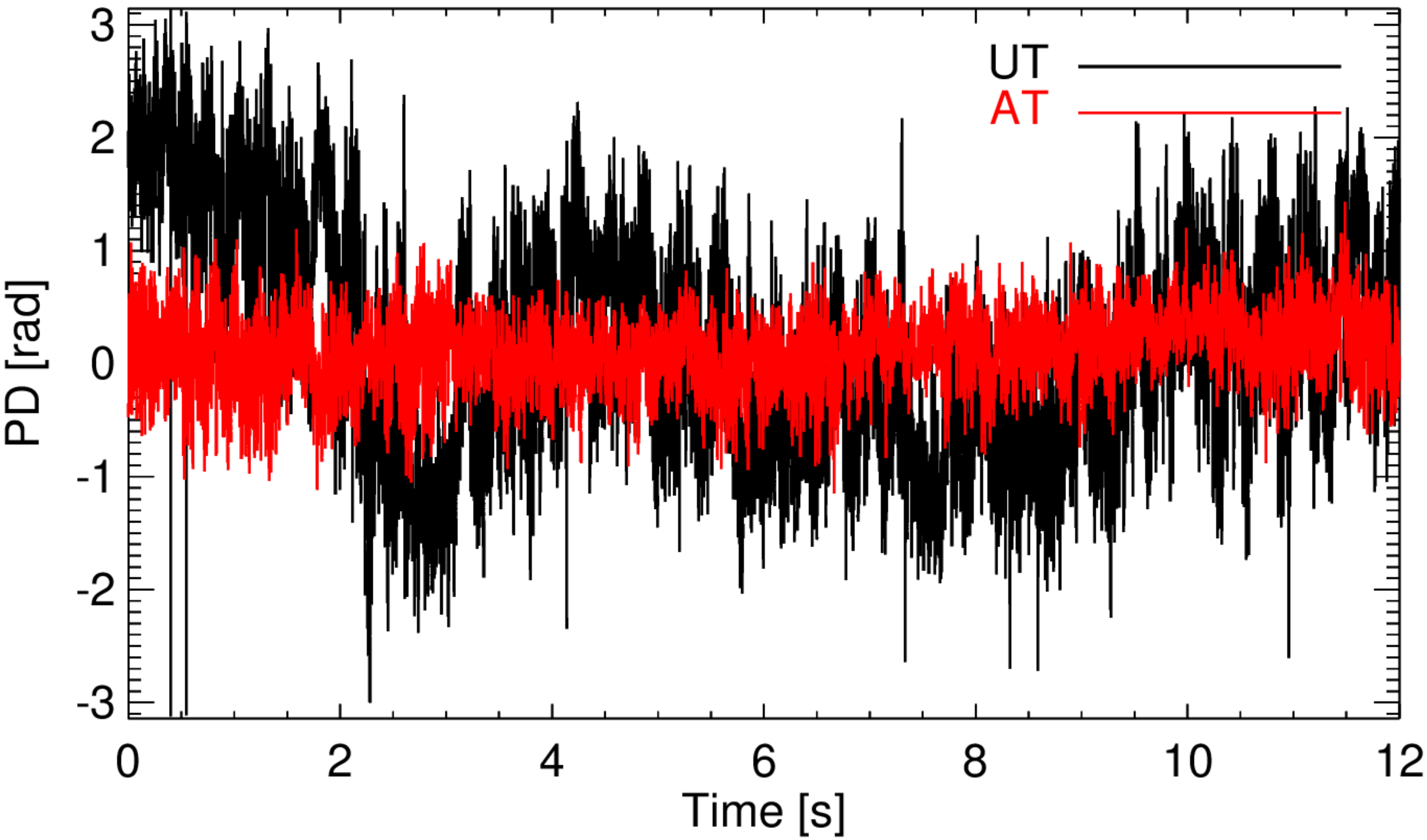




Müller, Pott et al., 2014, subm.

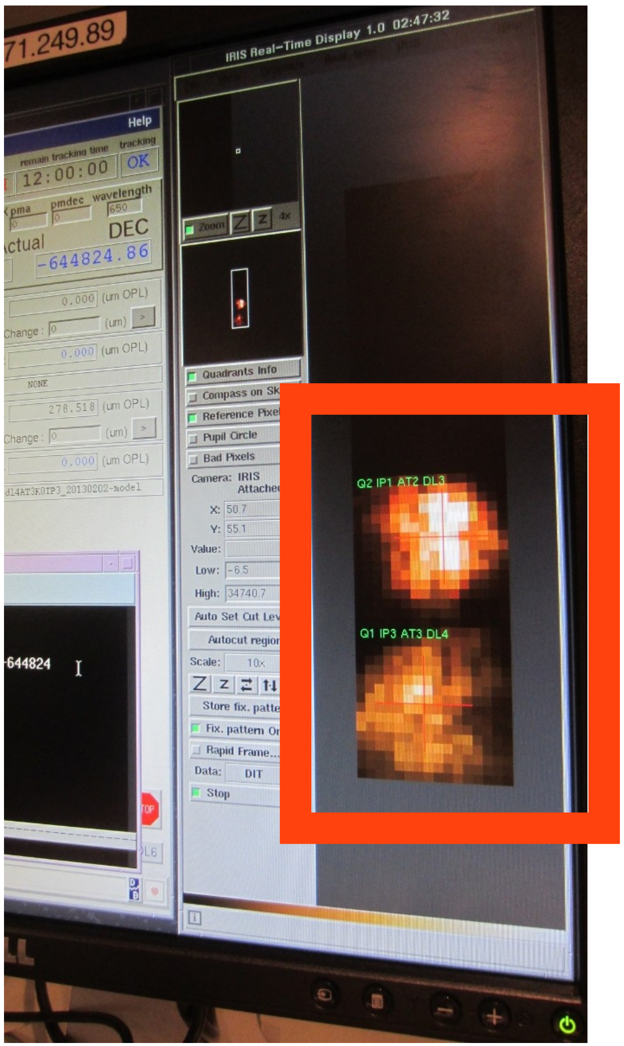
Limitations / Problems

- UTs: vibrations

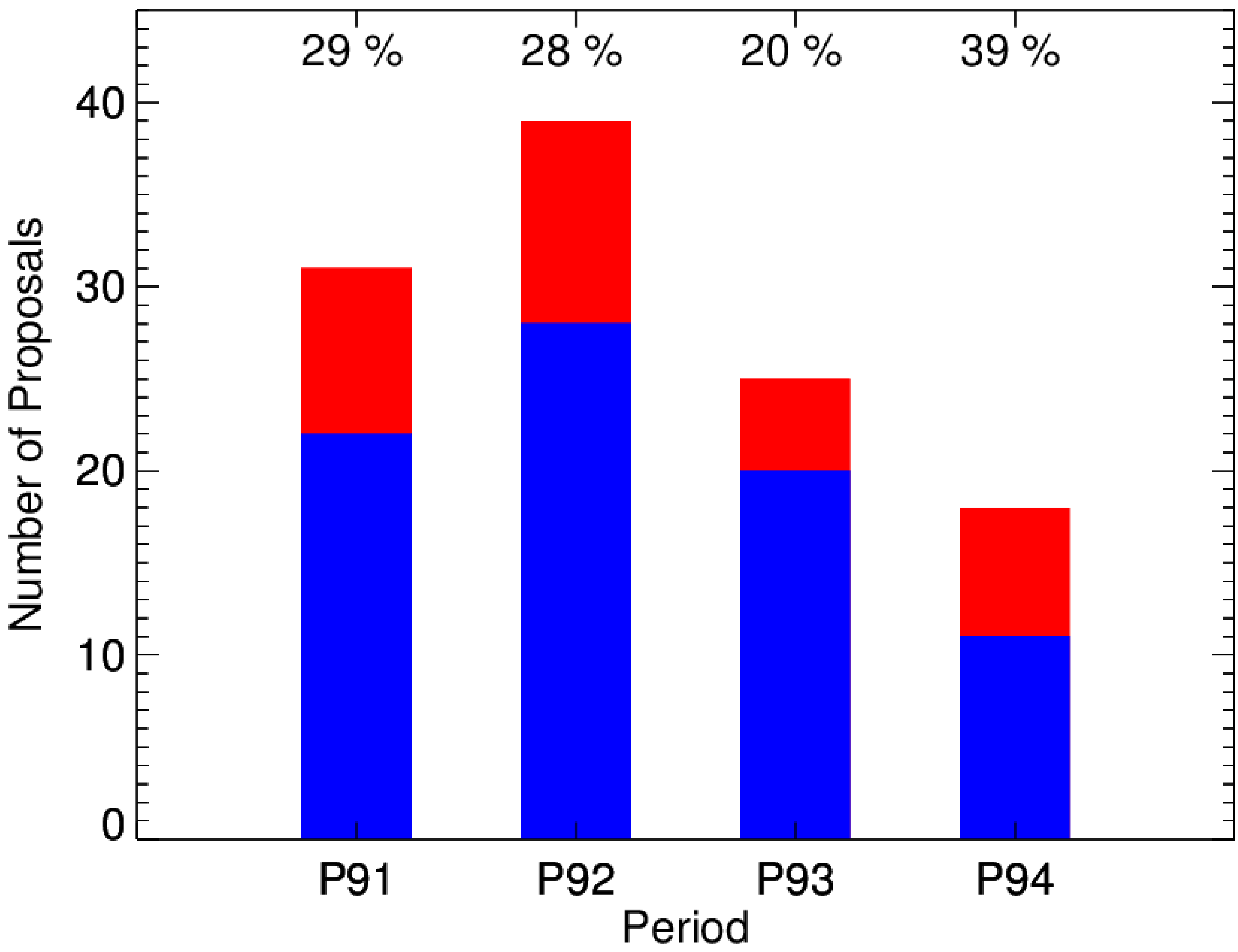


Limitations / Problems

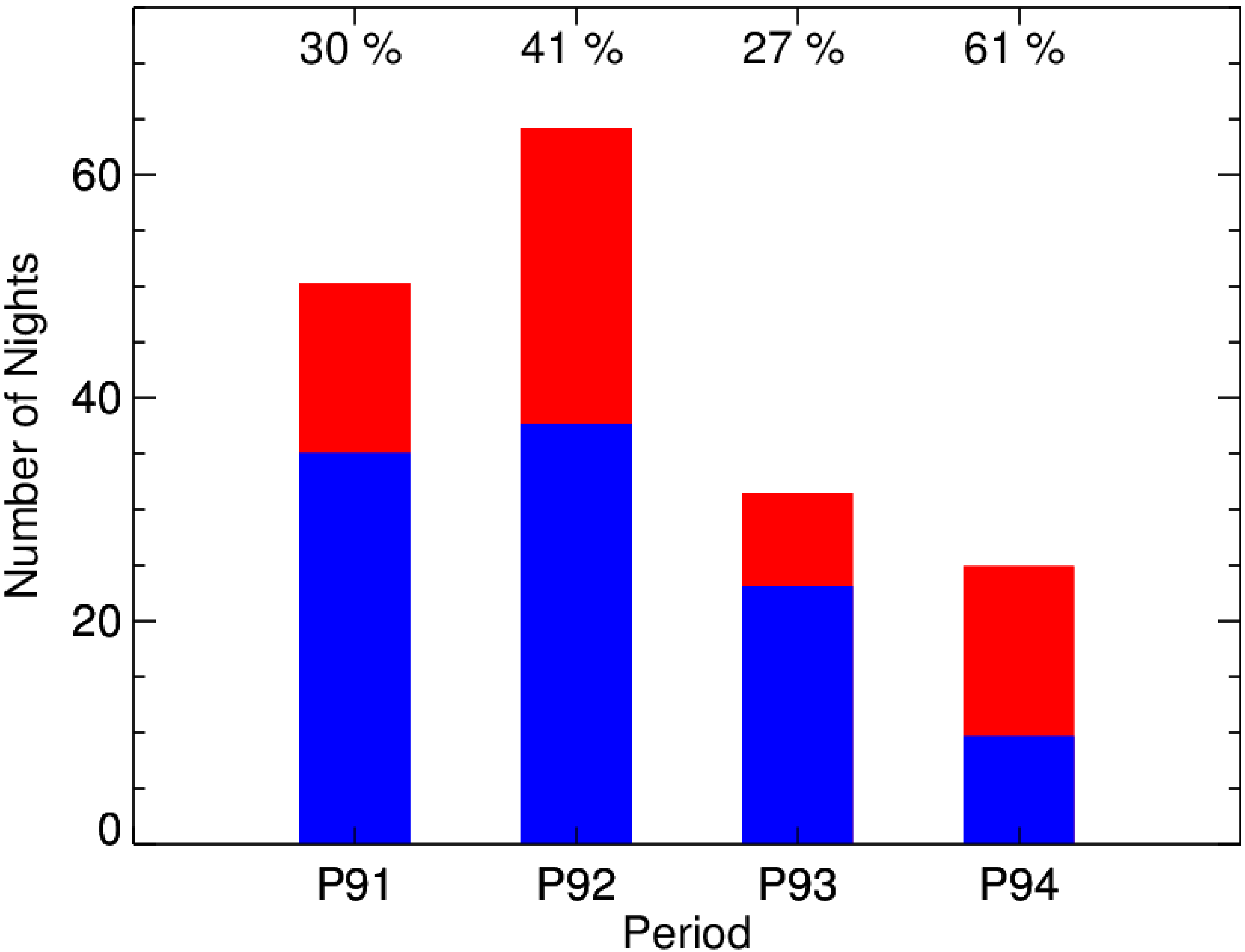
- ATs: wind, no AO correction (future NAOMI)



Statistics - Proposals



Statistics – Requested Nights



Conclusion

- MIDI+FSU-A works very well
- Increase of sensitivity (constant MIDI DIT)
- ATs: K<9.5mag, N>0.5Jy (vs. 10Jy)
- UTs: K<9.5mag (vibrations), N>~50mJy (vs. 200mJy)
- “Simultaneous” K-band visibilities