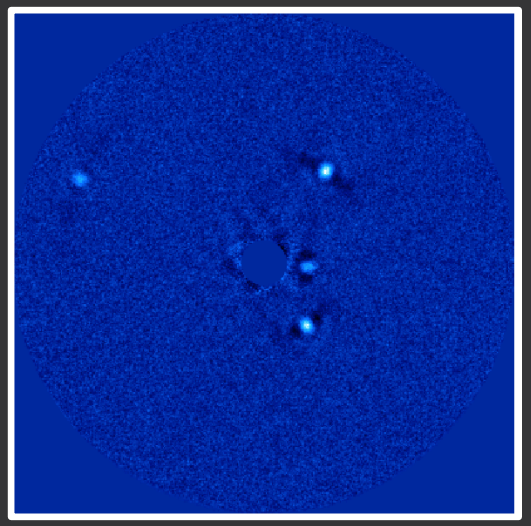
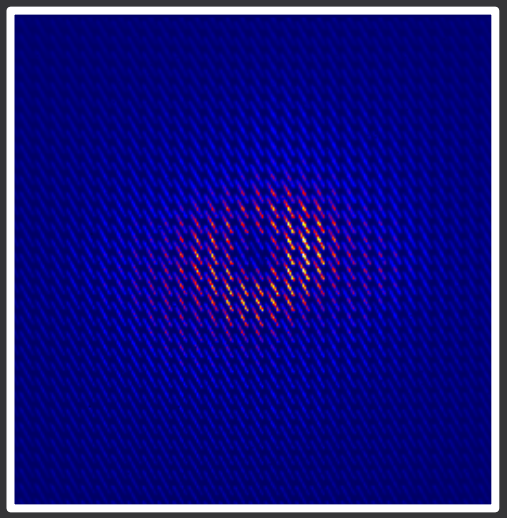
Latest results with LBTI's VORTEX coronagraph

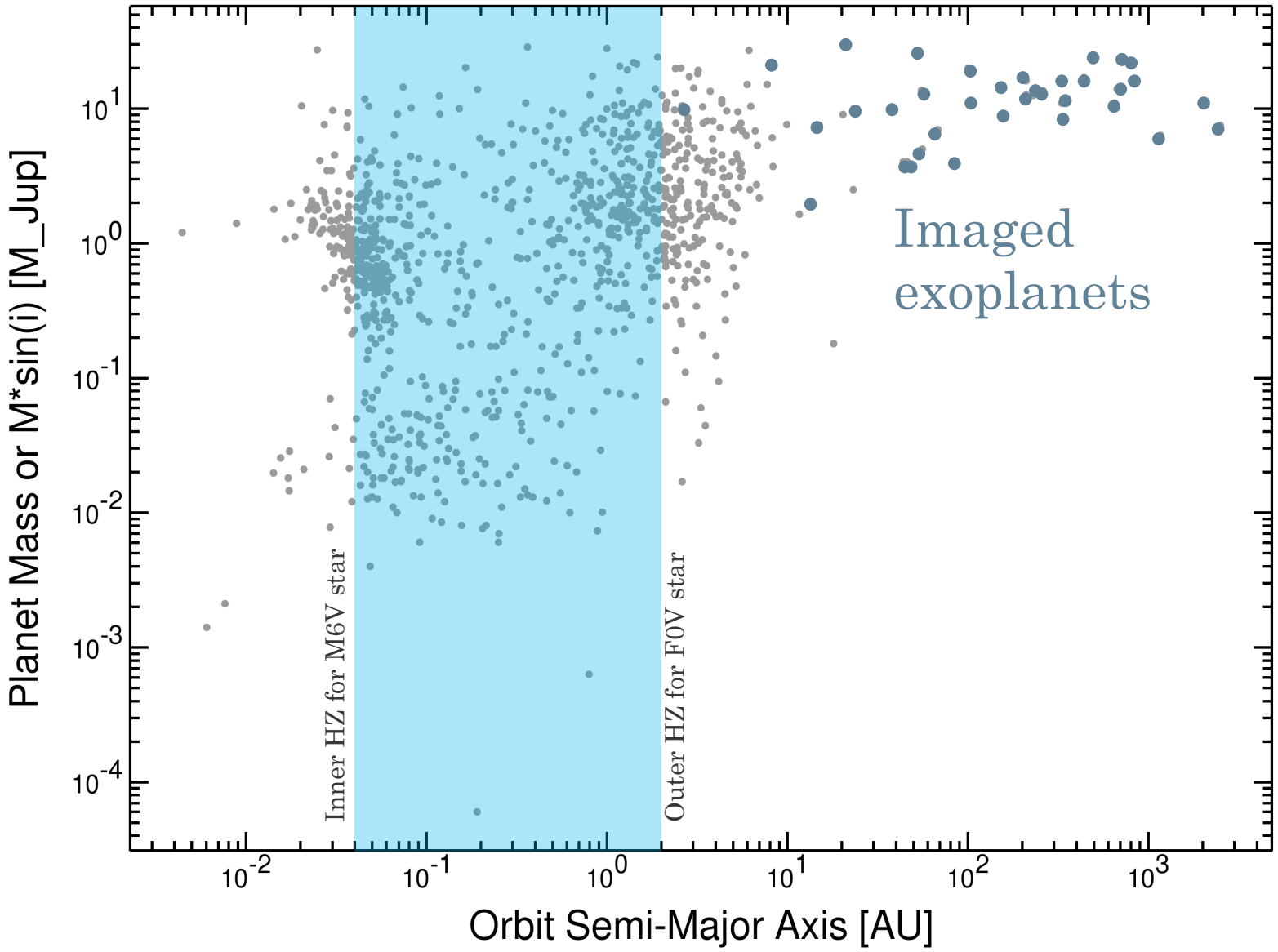
D. Defrère
University of Liège





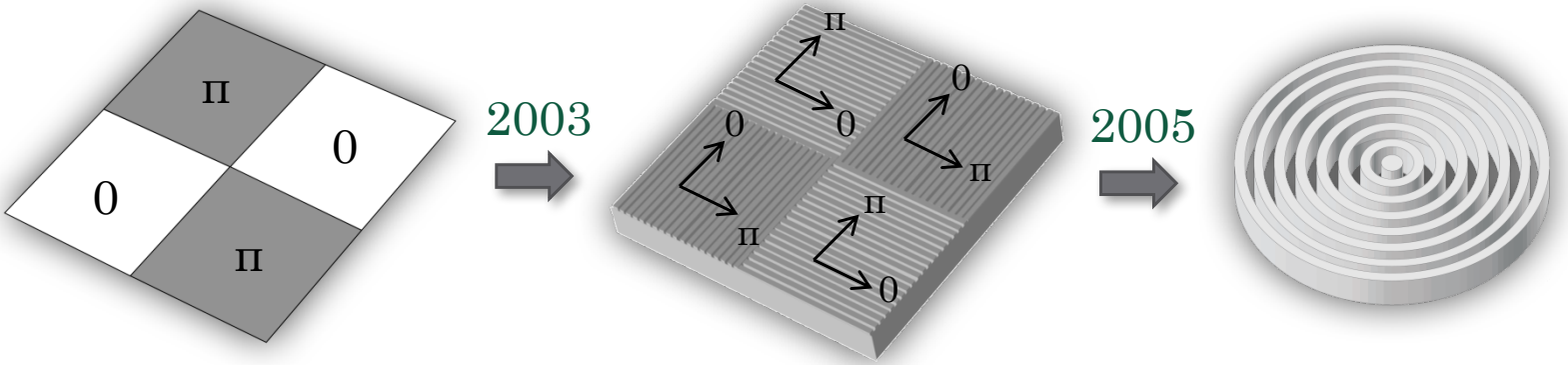
LBT user meeting -- Florence – June 23rd

Which planets?

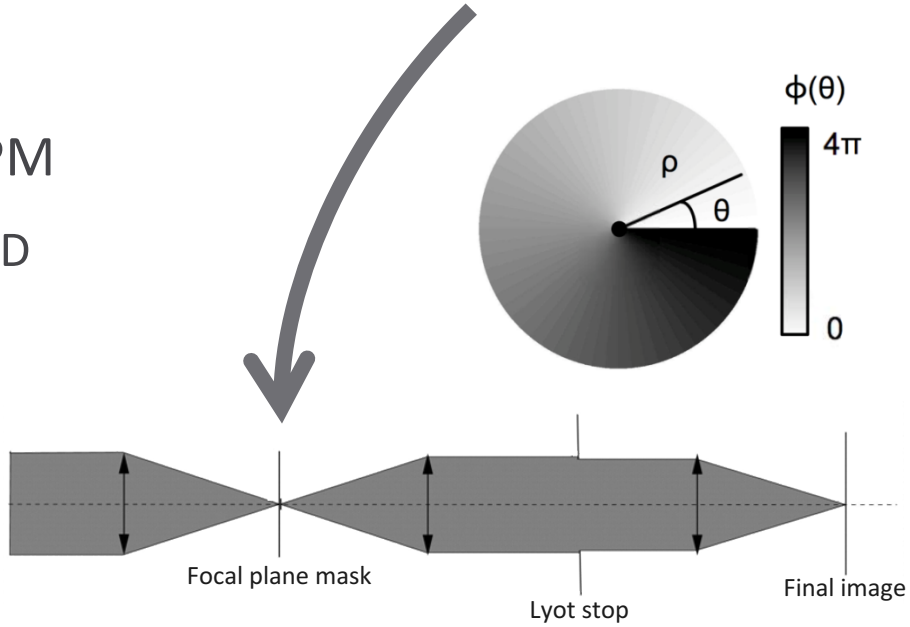


The birth of a concept

- FQPM → sub-wavelength gratings → Annular Groove PM

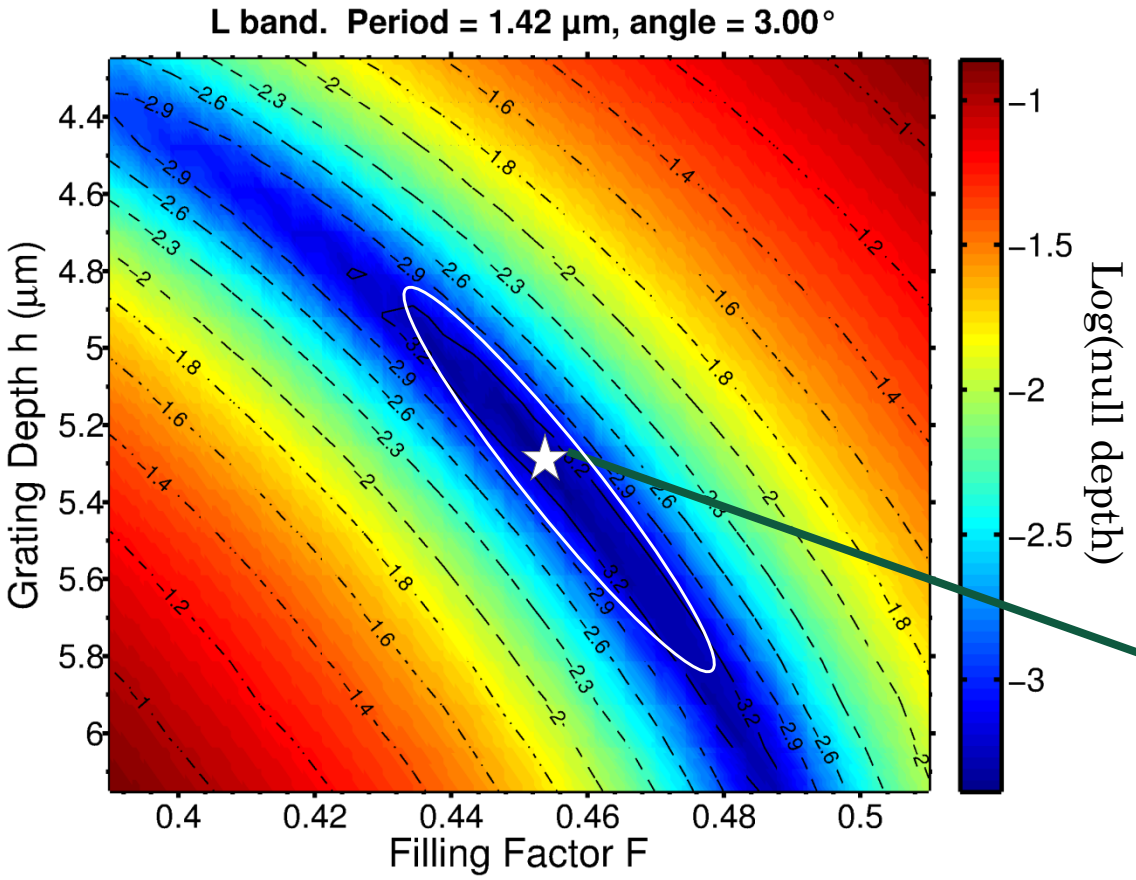


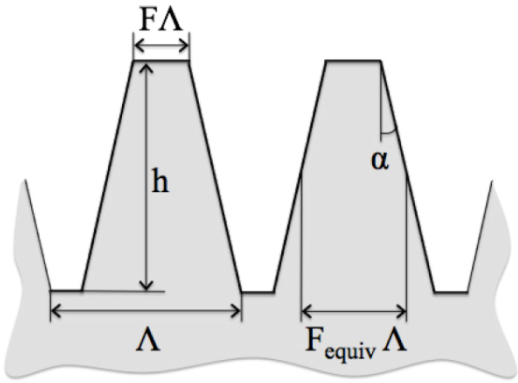
- Advantages of the AGPM
  - Inner working angle ≈ 1 λ/D
  - Clear 360° discovery space
  - Achromatic (SG design)
  - Easy to implement

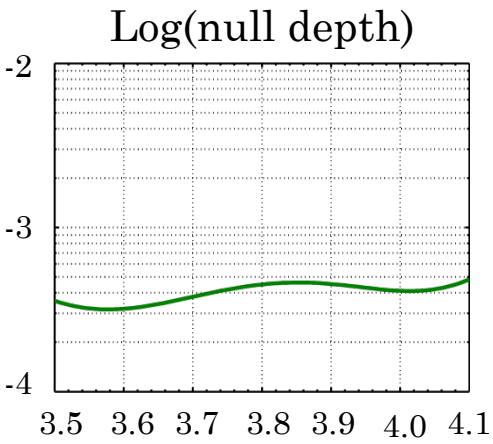


Mawet, Riaud, Absil & Surdej 2005

Grating design and optimization





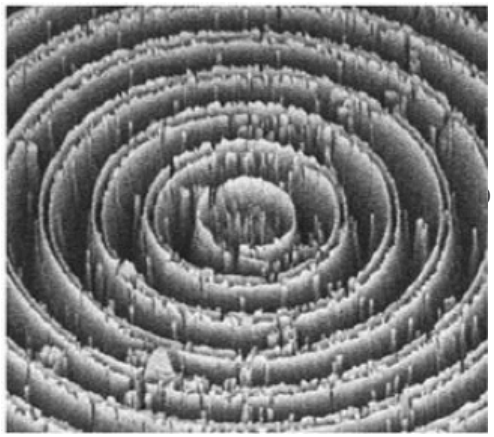


Delacroix et al. 2013

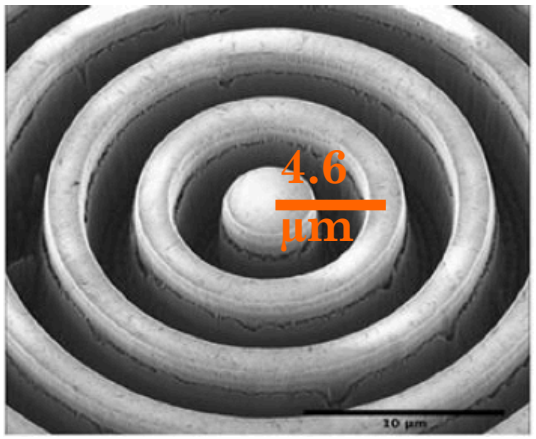
Etching on synthetic diamond

- Inductively coupled plasma etching
  - N band (grating period = 4.6 µm)
  - L band (grating period = 1.4 µm)

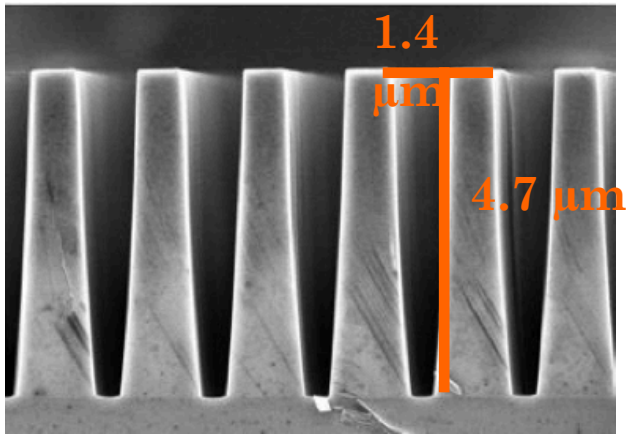
N band (Nov 2009)



N band (Feb 2012)



L band (Sep 2012)

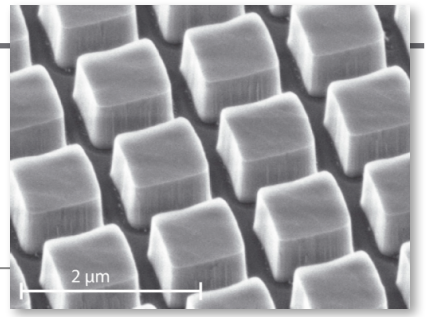


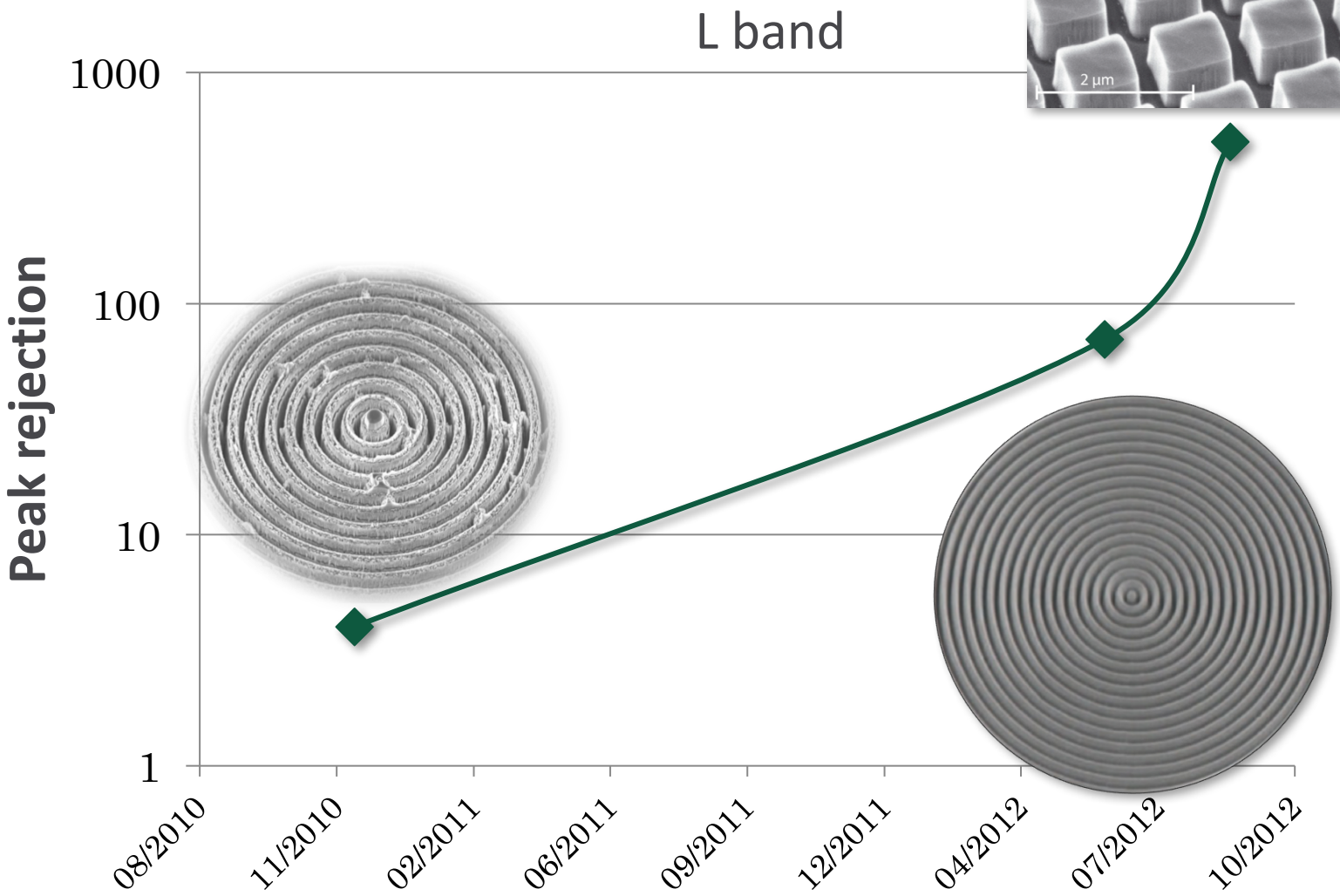
- Parameters close to optimal … need to test!

Forsberg & Karlsson 2013

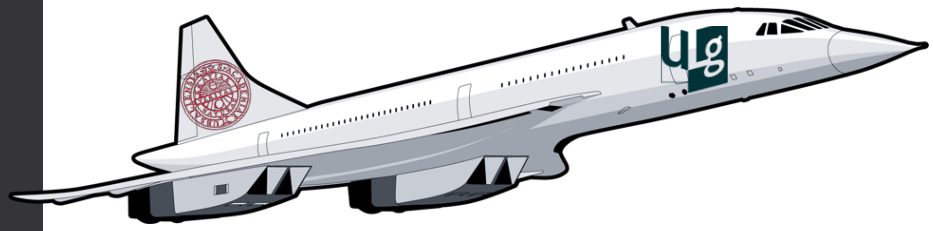
High performance

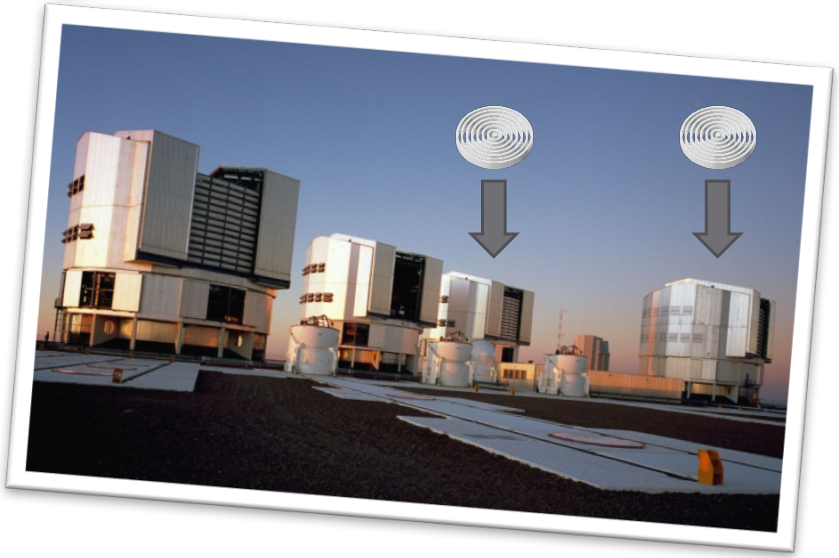
Delacroix et al. 2013





Installation at VLT, LBT, and Keck

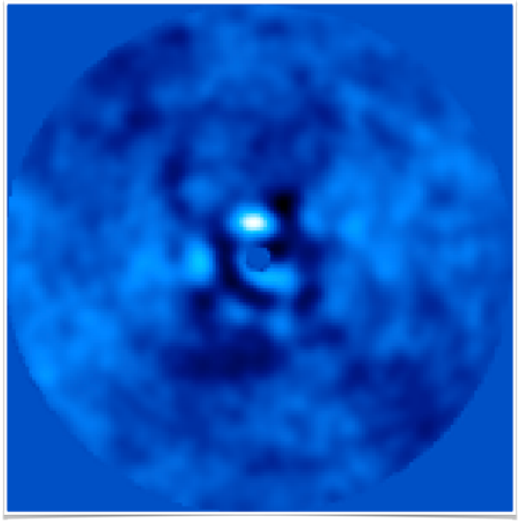




Installation at VLT, LBT, and Keck

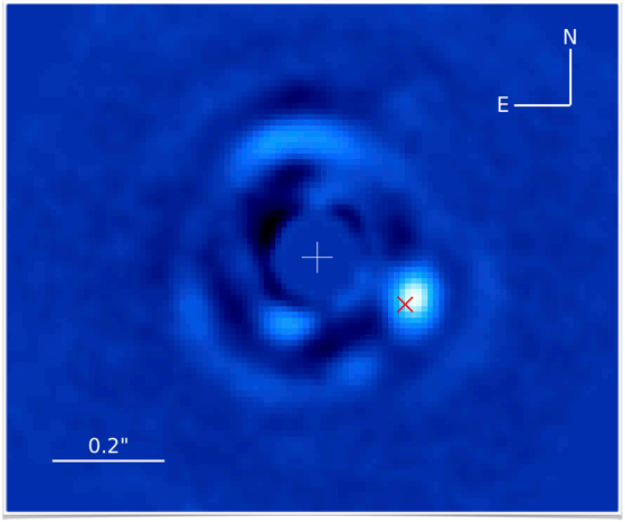
Science highlights

HD 169142 @ VLT/NACO



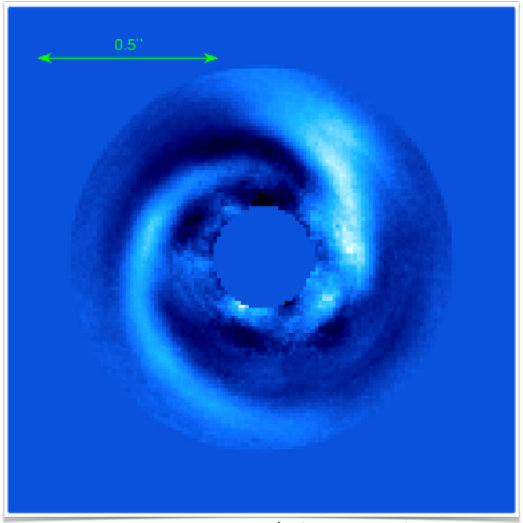
Biller et al. 2014, Reggiani et al. 2014

HIP 79124 @ Keck/NIRC2



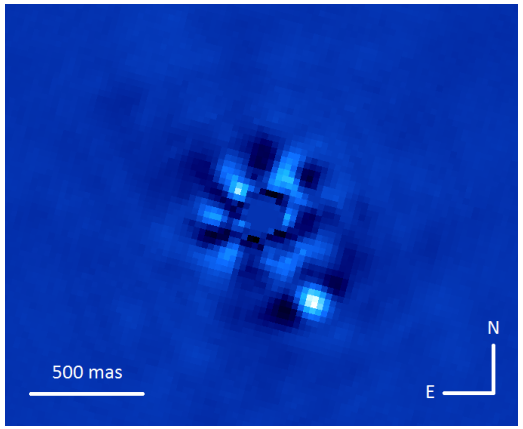
Serabyn et al. (2017)

MWC 758 @ Keck/NIRC2



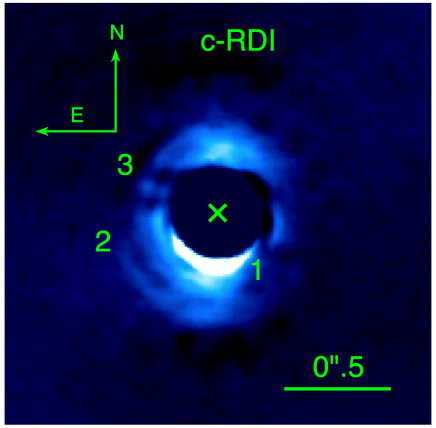
Reggiani et al. (in prep)

Beta Pic @ VLT/NACO

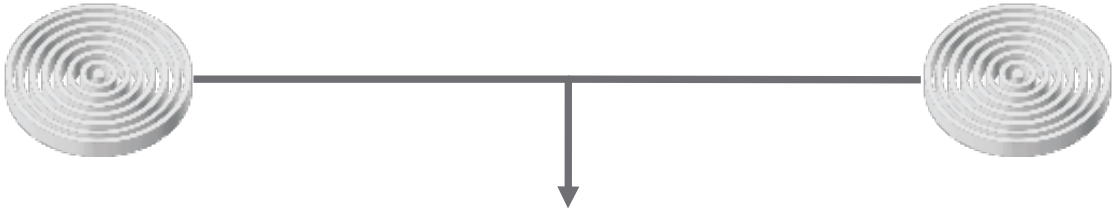


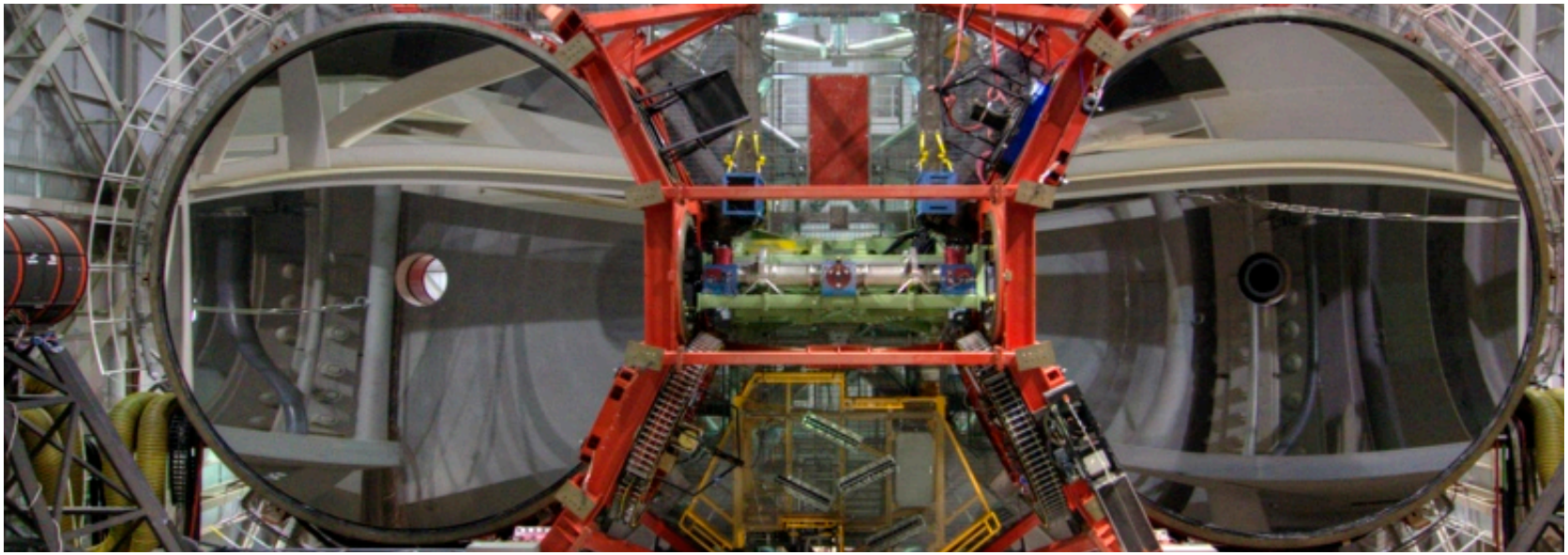
Absil et al. 2013

HIP 141569 @ Keck/NIRC2



VORTEX coronagraphy at the LBT





Resolution
Beam combination provides the equivalent resolution of a 22.7-m telescope.

High Contrast
The AO system creates an image with a Strehl of >90% at 3.8 µm.

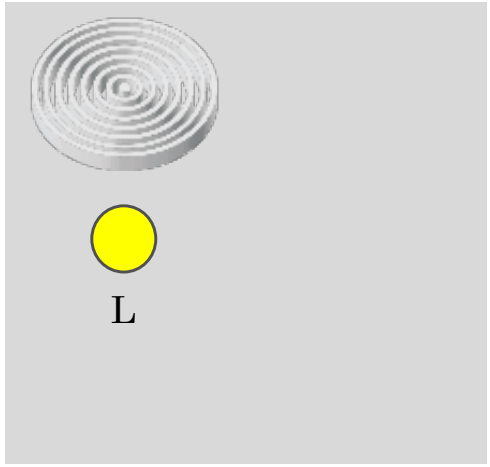
Sensitivity
LBT has two 8.4-m mirrors mounted on a single structure (collecting area of a single 11.8-m aperture)

LMIRCam specifications

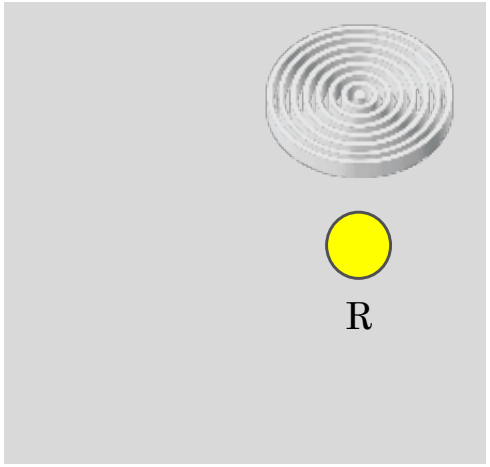
	LMIRcam	AGPM+LMIRCAM
Wavelength Coverage (µm)	J,H,K,L,M (1.5-5.1)	L&M (3.2-5.1)
Throughput	>30%	>30%
Pixel Size	0.011"	0.011"
FOV	40x40"	5x5"
Minimum Strehl	90% (3.8 µm)	90% (3.8 µm)
Spectral Resolution	350	40 (with IFU)
Spatial Resolution	40 mas @ L'	40 mas @ L'

Several possibilities

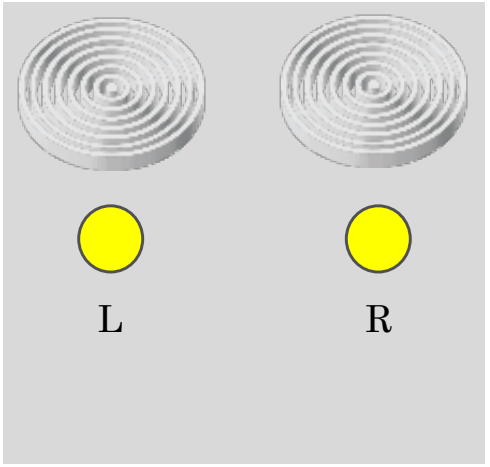
Single AO+AGPM imaging



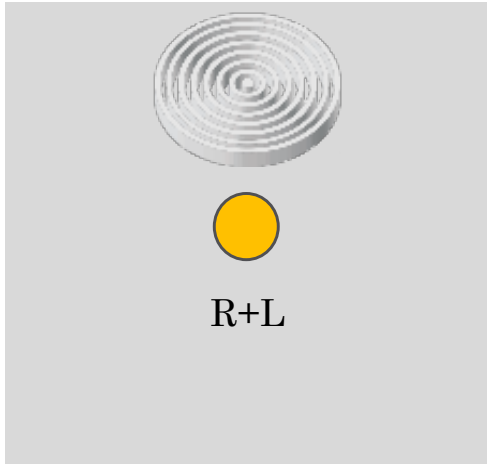
Single AO+AGPM imaging

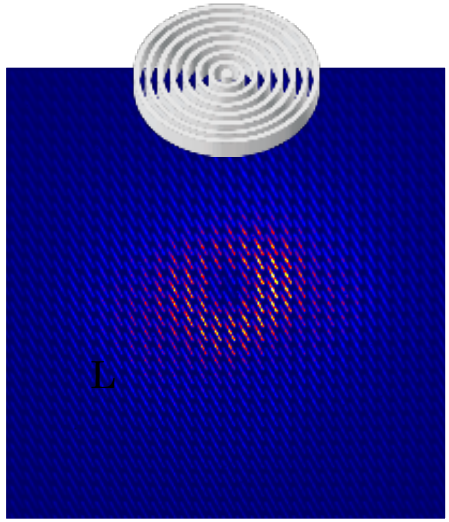


Binocular AO+AGPM imaging



Binocular AO+AGPM imaging

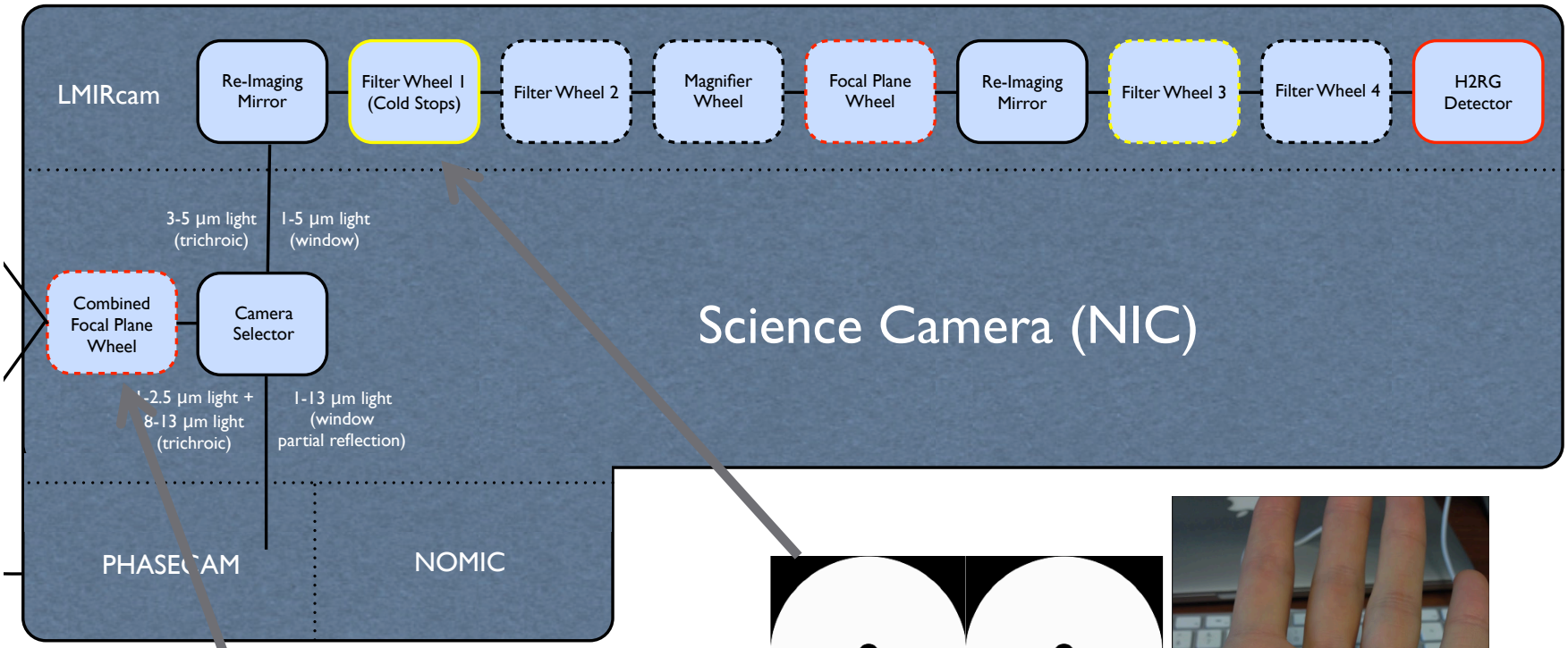


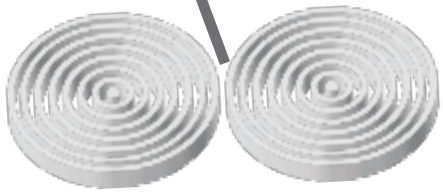


New mode

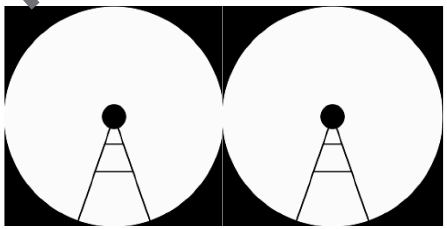
Single IFU+AO+AGPM imaging

AGPM: easy to install





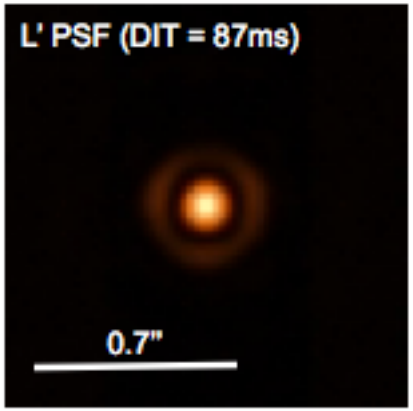
2015 (AGPM-L4&B8D2)

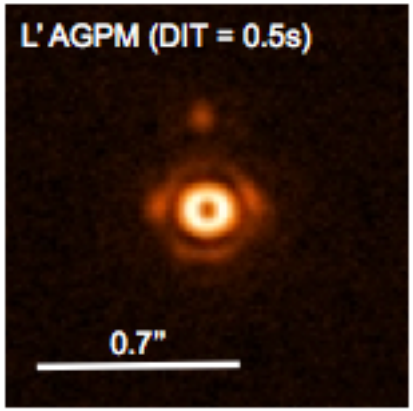


New optimized Lyot stop

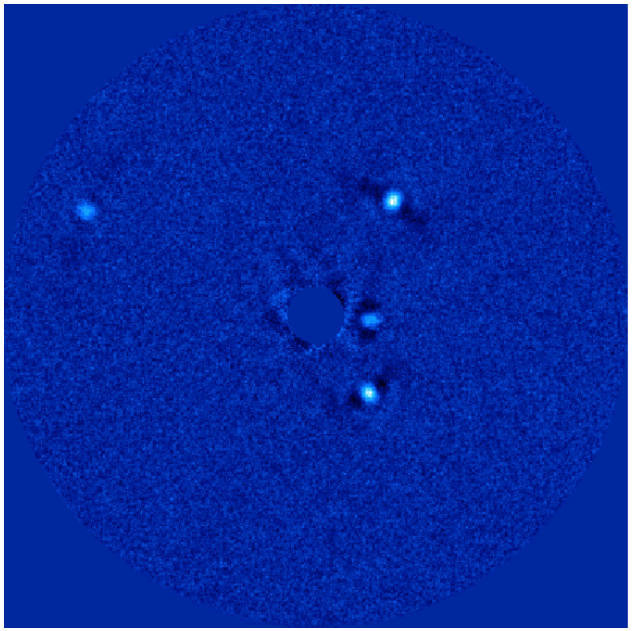
Nov. 2013: first-light observations

- First-light observations on October 17, 2013 (AGPM-L4, **1 telescope**):



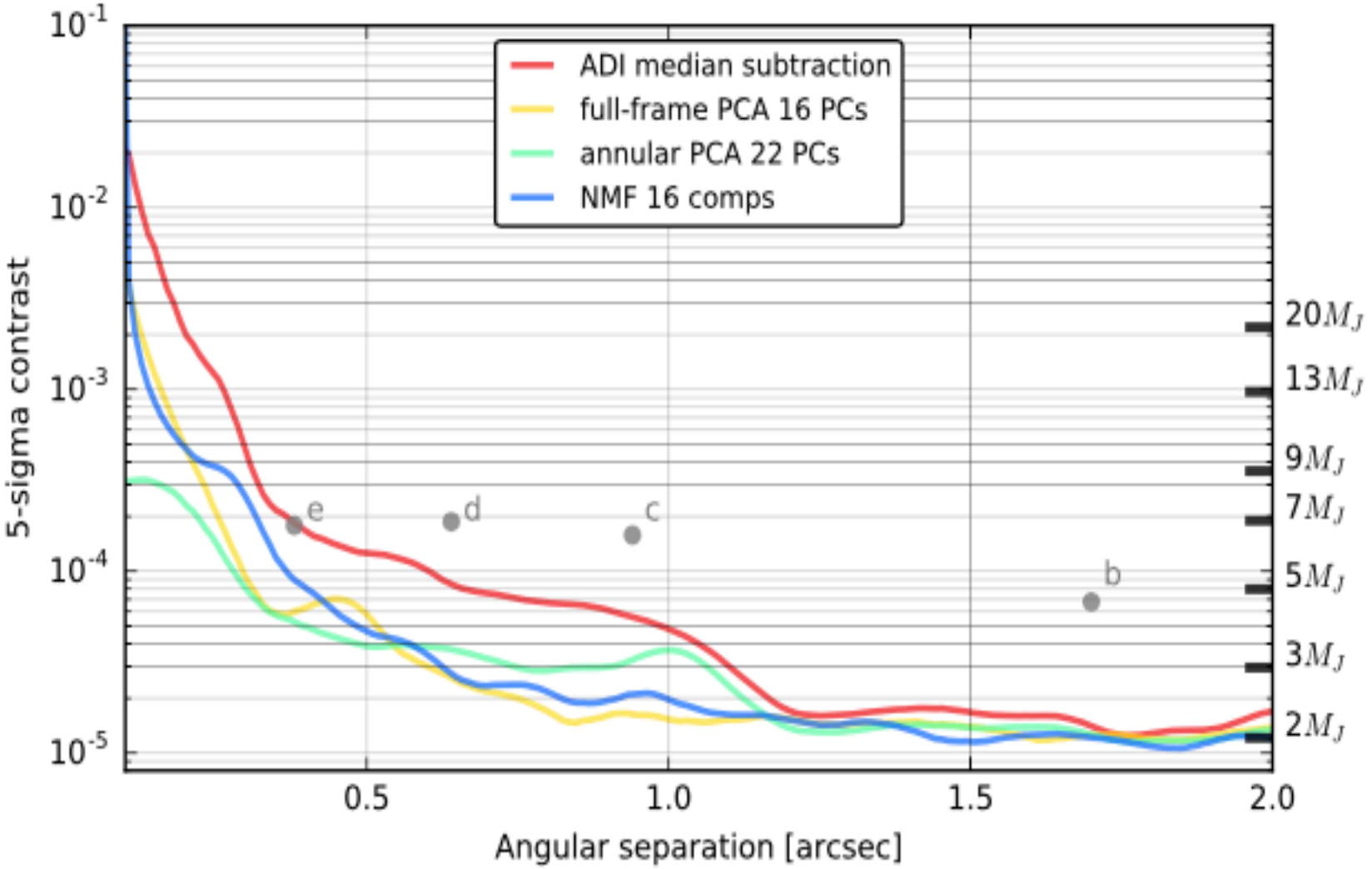


Peak rejection ~35:1
(far from optimal)



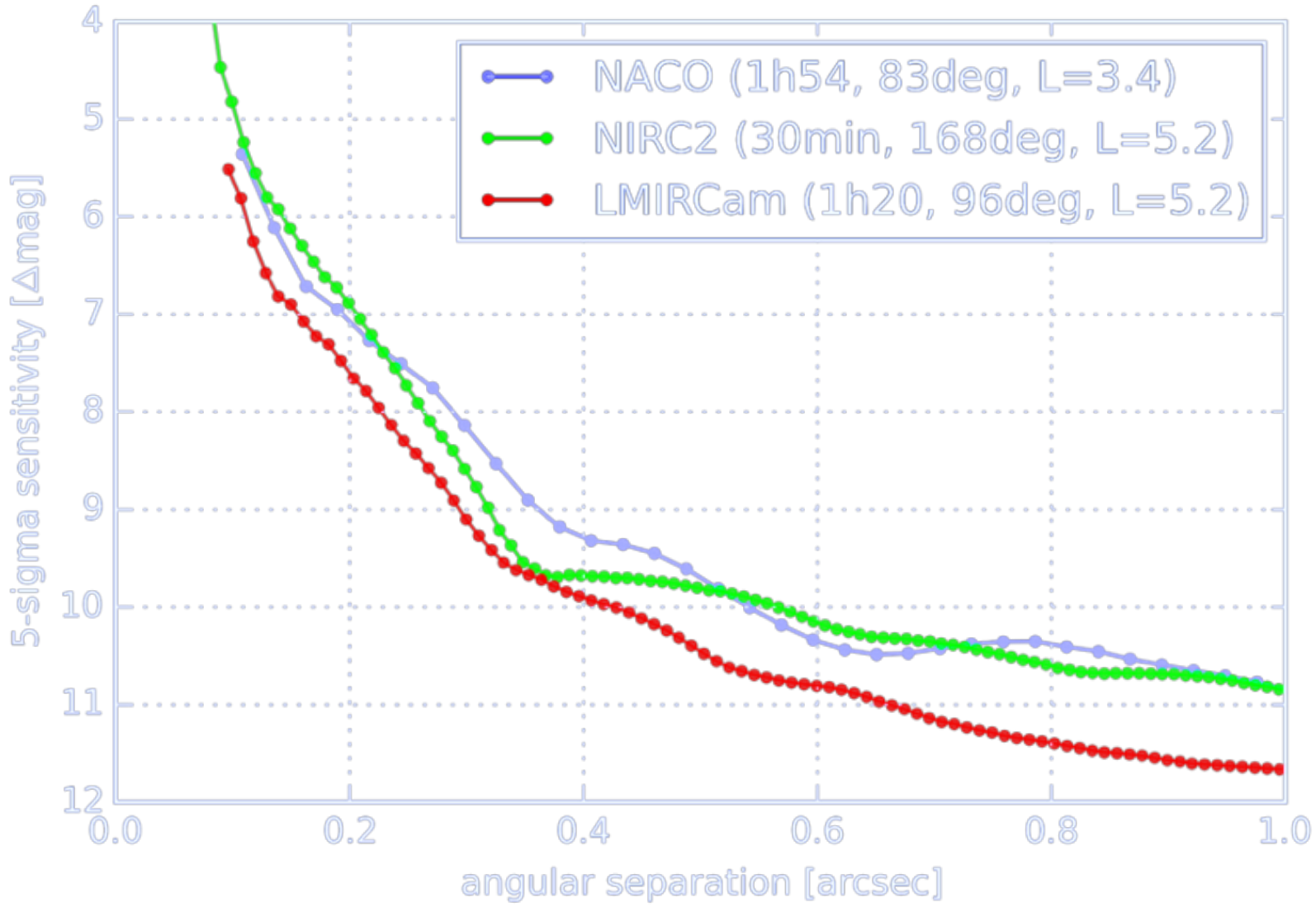
Gomez et al. 2017

Nov. 2013: first-light observations

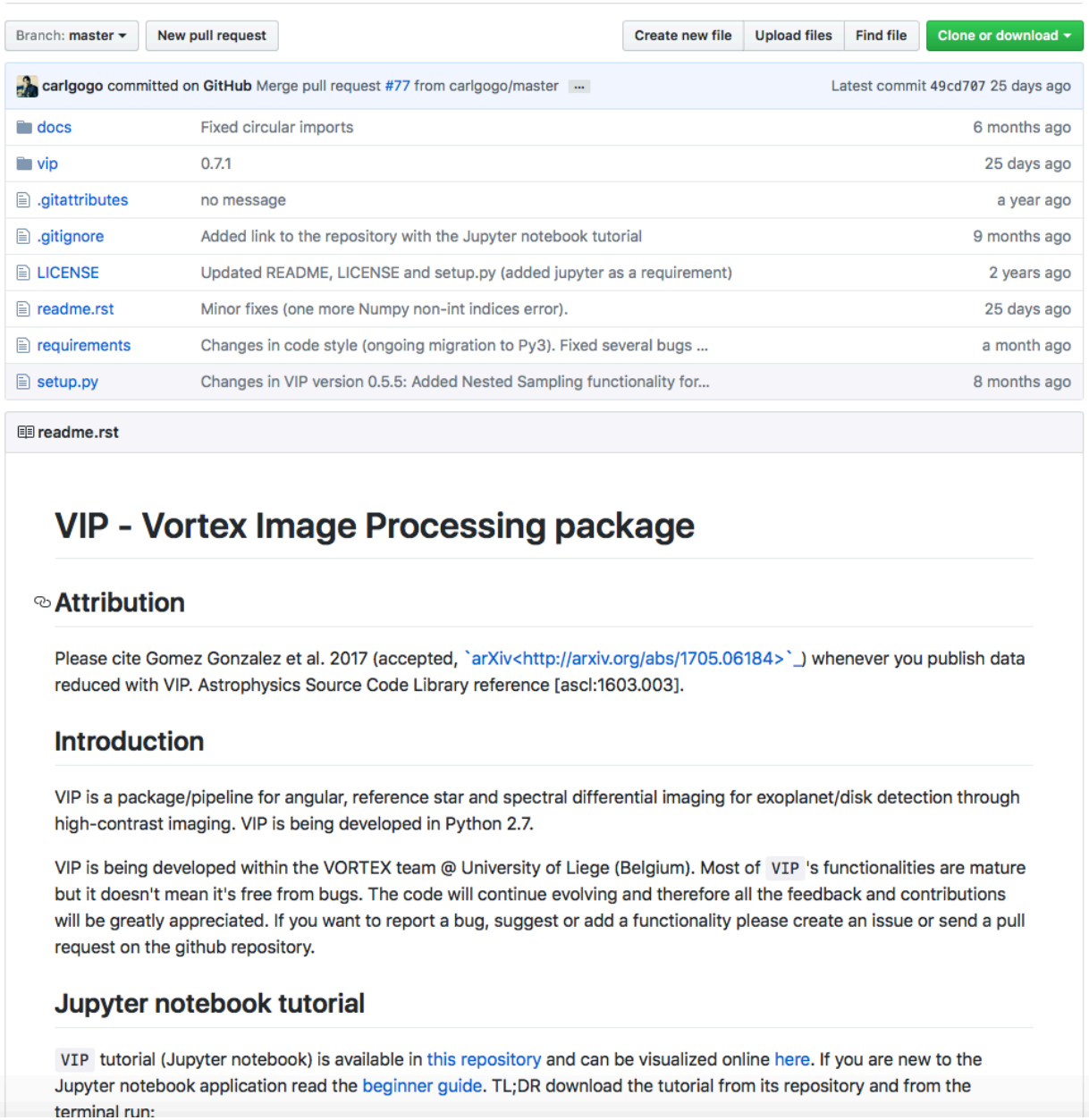


Gomez et al. 2017

Comparison with other instruments



VIP library: http://github.com/vortex-exoplanet/VIP



Branch: master ▾ | New pull request | Create new file | Upload files | Find file | Clone or download ▾

carlgogo committed on GitHub Merge pull request #77 from carlgogo/master ... Latest commit 49cd707 25 days ago

docs	Fixed circular imports	6 months ago
vip	0.7.1	25 days ago
.gitattributes	no message	a year ago
.gitignore	Added link to the repository with the Jupyter notebook tutorial	9 months ago
LICENSE	Updated README, LICENSE and setup.py (added jupyter as a requirement)	2 years ago
readme.rst	Minor fixes (one more Numpy non-int indices error).	25 days ago
requirements	Changes in code style (ongoing migration to Py3). Fixed several bugs ...	a month ago
setup.py	Changes in VIP version 0.5.5: Added Nested Sampling functionality for...	8 months ago

readme.rst

VIP - Vortex Image Processing package

Attribution

Please cite Gomez Gonzalez et al. 2017 (accepted, `arXiv<http://arxiv.org/abs/1705.06184>`_) whenever you publish data reduced with VIP. Astrophysics Source Code Library reference [ascl:1603.003].

Introduction

VIP is a package/pipeline for angular, reference star and spectral differential imaging for exoplanet/disk detection through high-contrast imaging. VIP is being developed in Python 2.7.

VIP is being developed within the VORTEX team @ University of Liege (Belgium). Most of `VIP` 's functionalities are mature but it doesn't mean it's free from bugs. The code will continue evolving and therefore all the feedback and contributions will be greatly appreciated. If you want to report a bug, suggest or add a functionality please create an issue or send a pull request on the github repository.

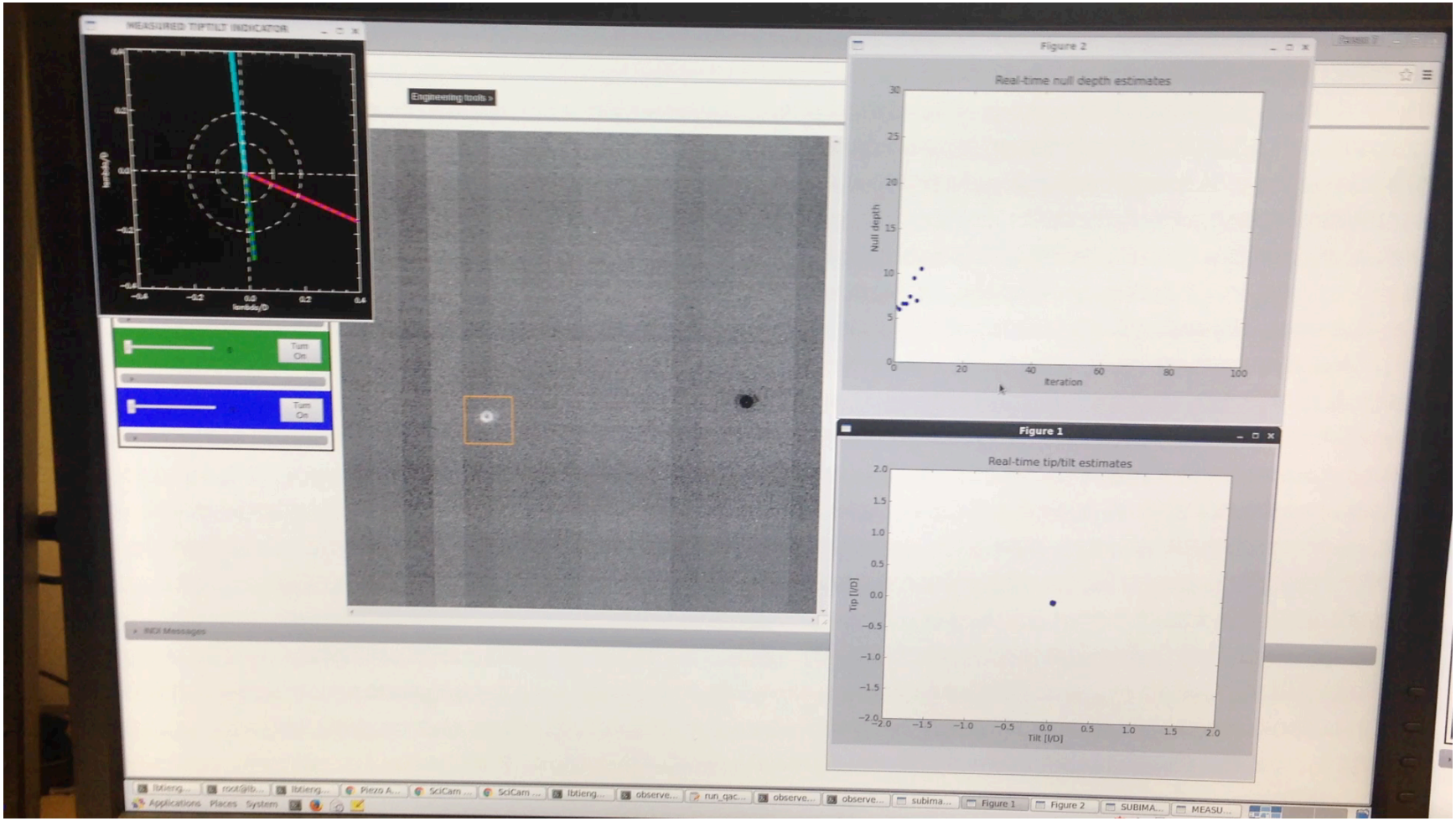
Jupyter notebook tutorial

`VIP` tutorial (Jupyter notebook) is available in this repository and can be visualized online here. If you are new to the Jupyter notebook application read the beginner guide. TL;DR download the tutorial from its repository and from the terminal run:

New improvements

(Huby et al. 2015)

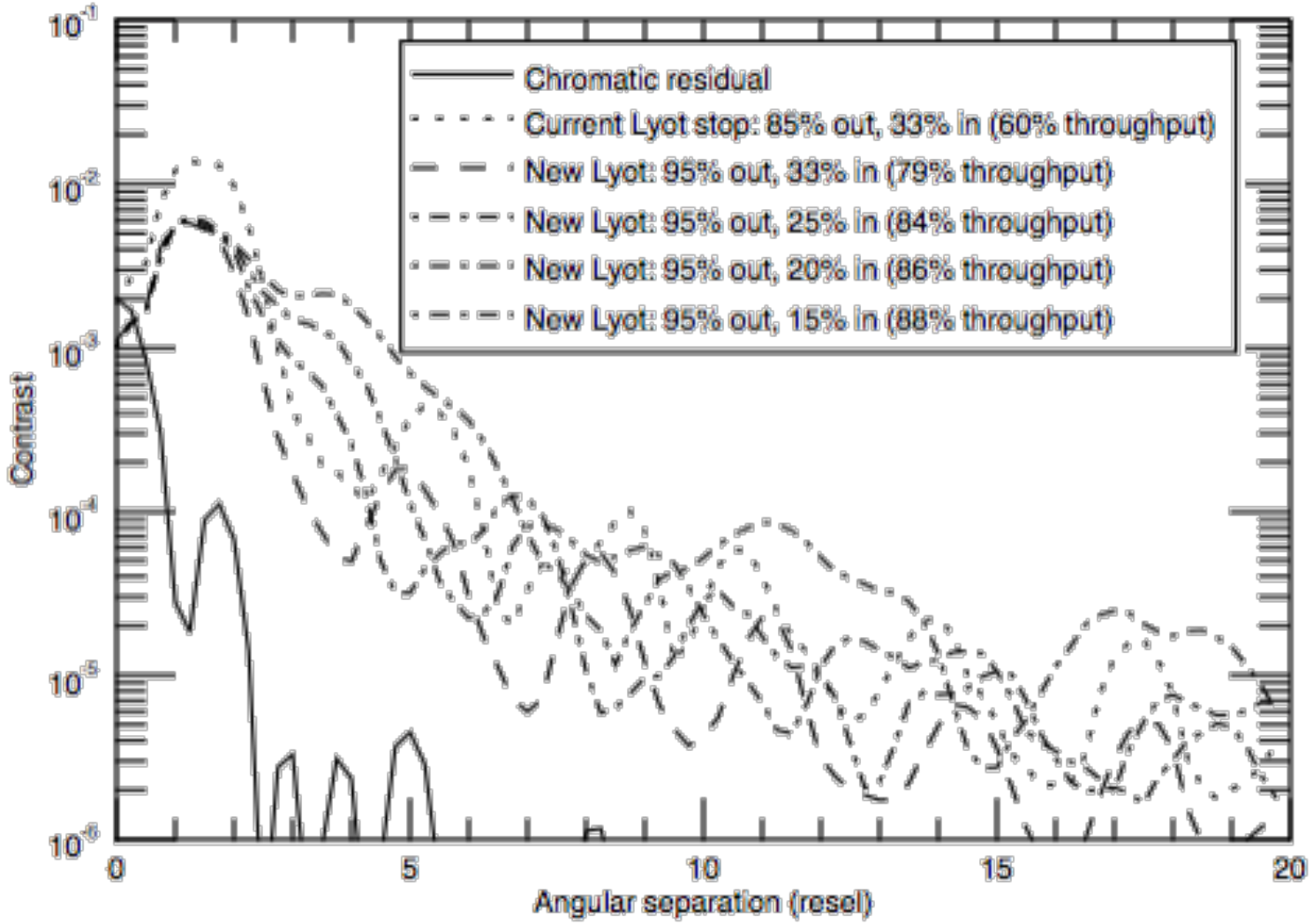
- 1. Real-time star centroiding using QACITS



New improvements

PROPER simulation done by D. Mawet

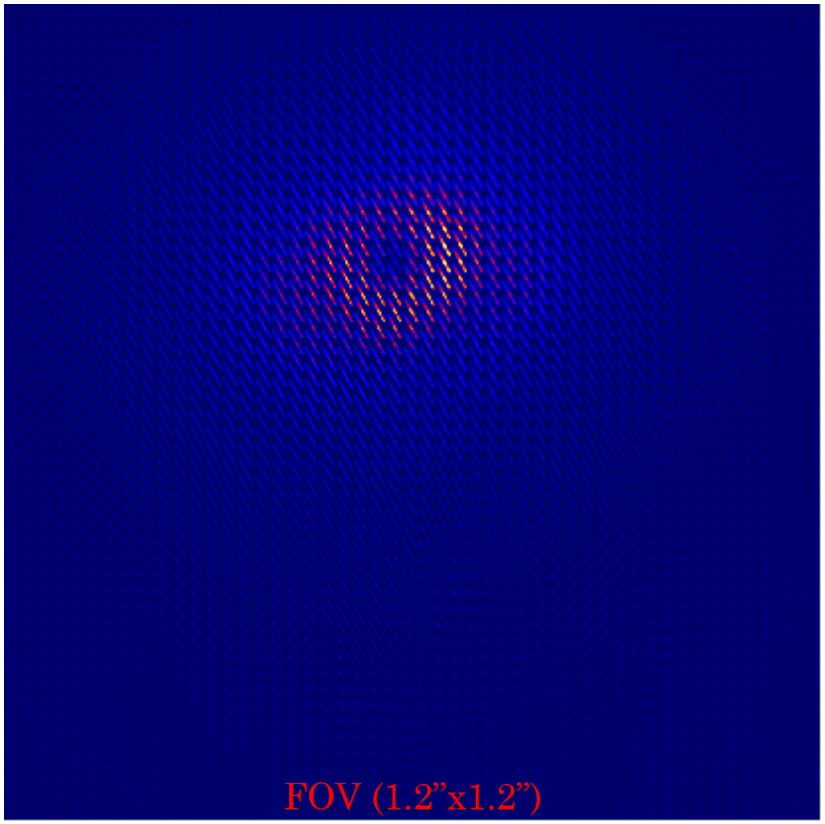
- 2. New optimized Lyot stop



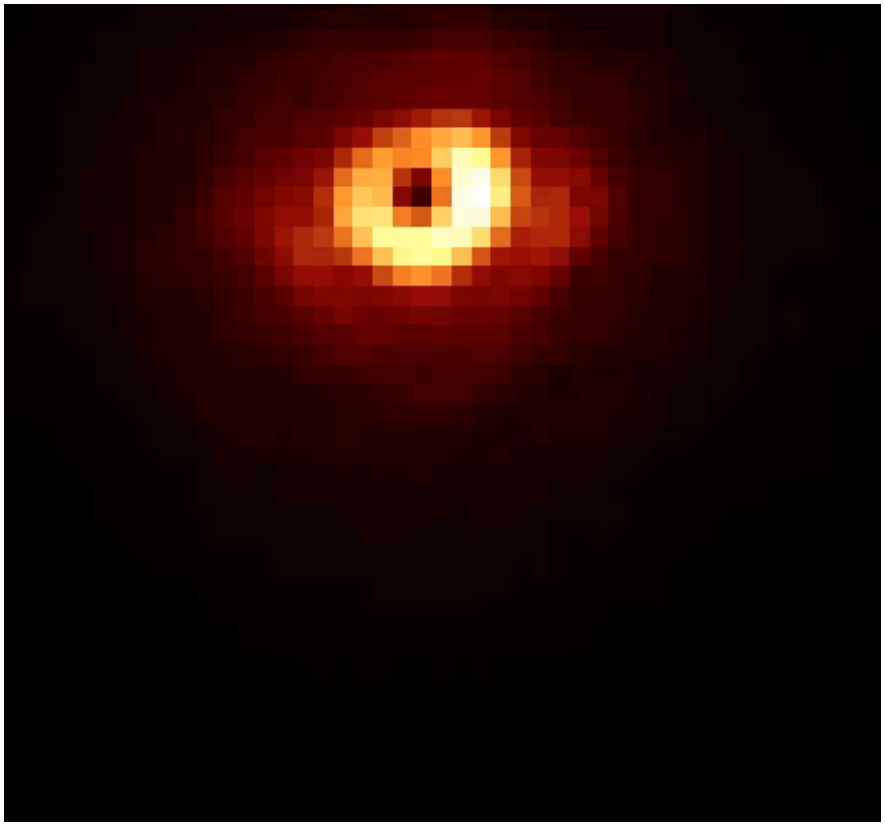
New improvements

- 3. New AGPM+IFU mode

First AGPM+IFU image (beta Aur)



Spectral image cube (2.8 – 4.2 microns, R~20)

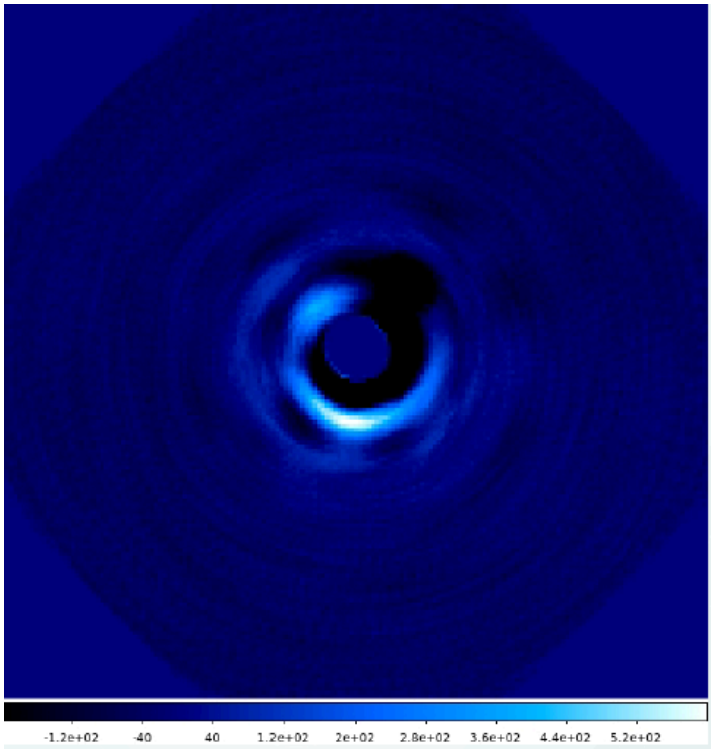


Data processing by Jordan Stone (UoA)

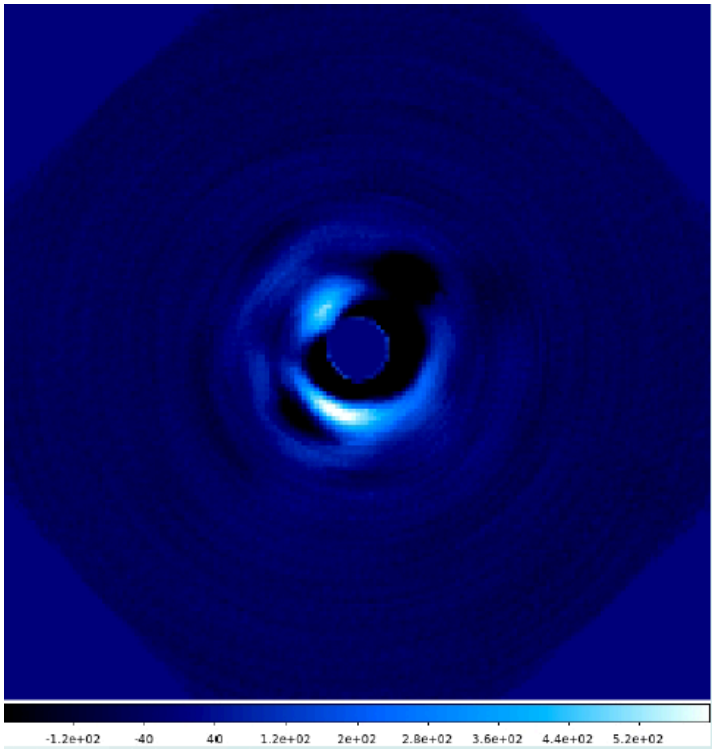
Latest observations

- Planet formation at small angular separation
  (preliminary)

Left AGPM



Right AGPM



Summary

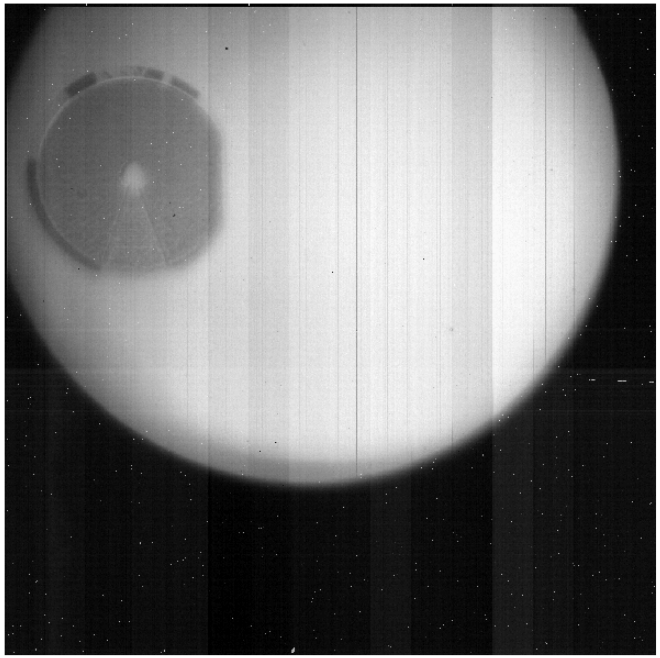
- LMIRCam+AGPM for L' high-contrast imaging
- New optimized Lyot stop and two AGPMs for binocular observations
- New IFU + AGPM mode (R=40)
- New real-time tip/tilt loop (improve efficiency and contrast)
- Want to use it?
  - AGPM contact: ddefrere@ulg.ac.be
  - LMIRCam contact: jstone@as.arizona.edu

Backup

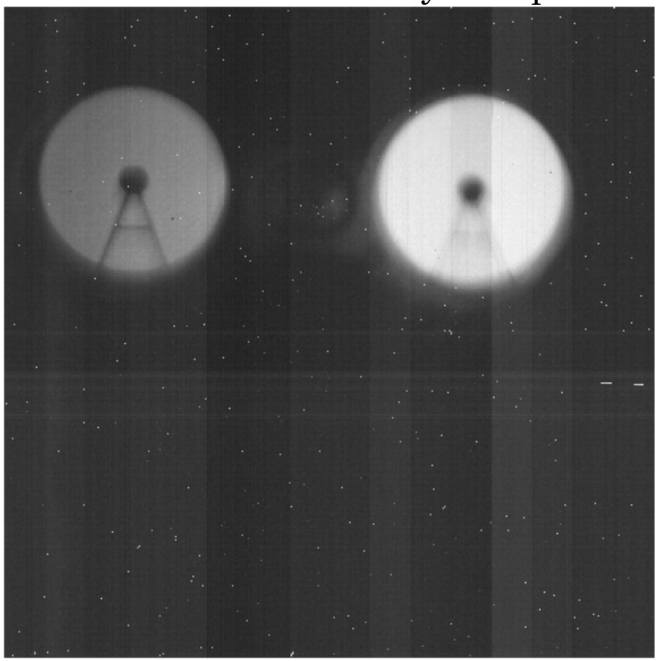
Recent results

- Squeezed in ~1hour of AGPM engineering in December 2016 (during ALES commissioning)
  - New double Lyot stop shows no issue
  - Alignment went smoothly;

No Lyot stop

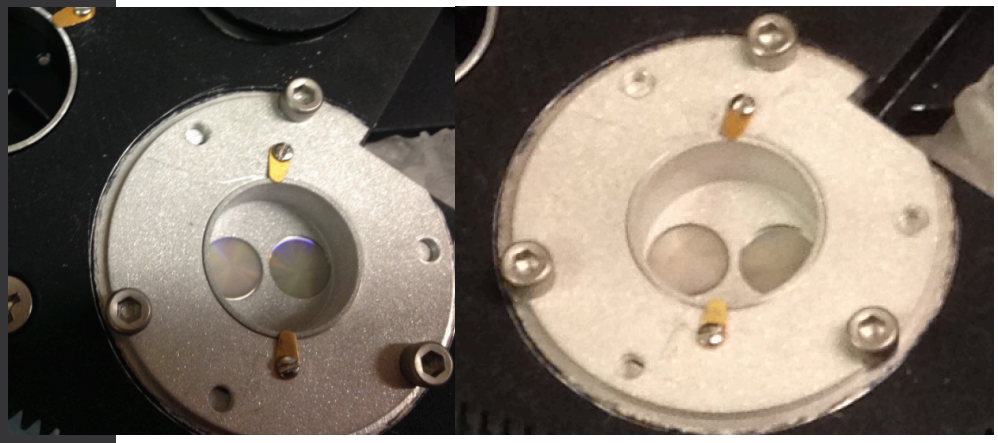


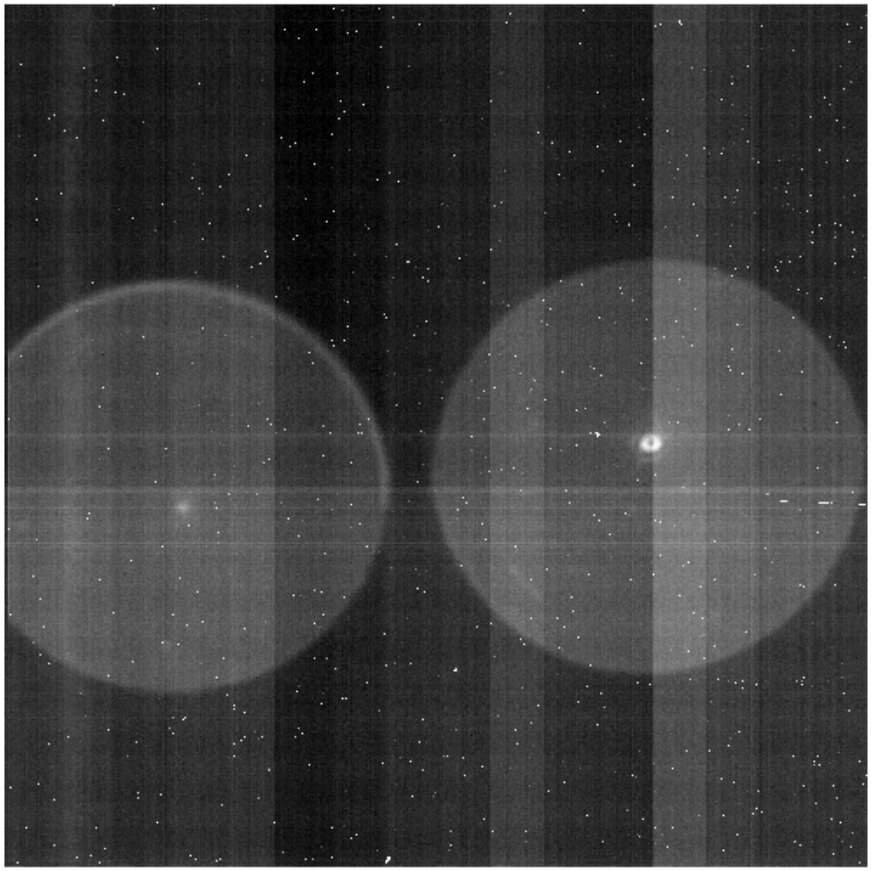
With new double Lyot stop



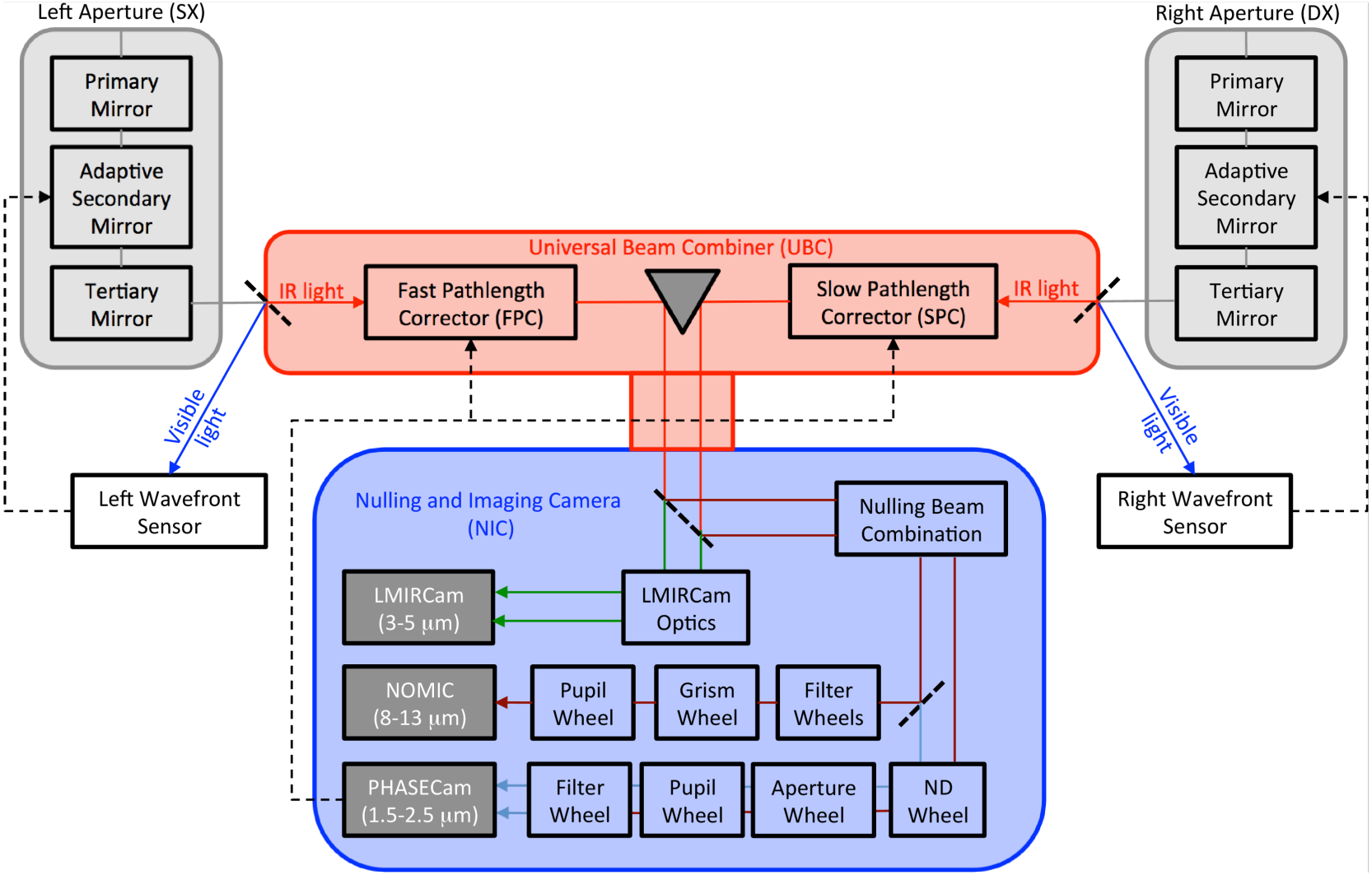
AGPM misaligned

- Both AGPMs fit nicely LMIRCam's field-of-view;
- The center of the right AGPM doesn't seem to appear at the center of the AGPM => mount cover has rotated.
- Example of clocked mount cover (left). Last picture before closing the cryostat (right):





The LBT interferometer (LBTI)



ALES (Arizona Lenslet for Exoplanet Survey)

Wavelength ranges / spectral resolutions:
2.8-4.15 (R~40)
3-5 (R~20)
2.2-3.7 (R~40)
2.0-2.3 (R~150)
3.1-3.5 (R~100)

FOVs / spaxel scales (the finest scales are for dual-aperture interferometry)
0.45x0.45" (6x6 mas spaxels)
0.9x0.9" (12 mas spaxels)
1.8x1.8" (25 mas spaxels)
3.6x3.6" (50 mas spaxels)