

**High Contrast Imaging
at Visible Wavelengths
with MagAO and its VisAO Camera**



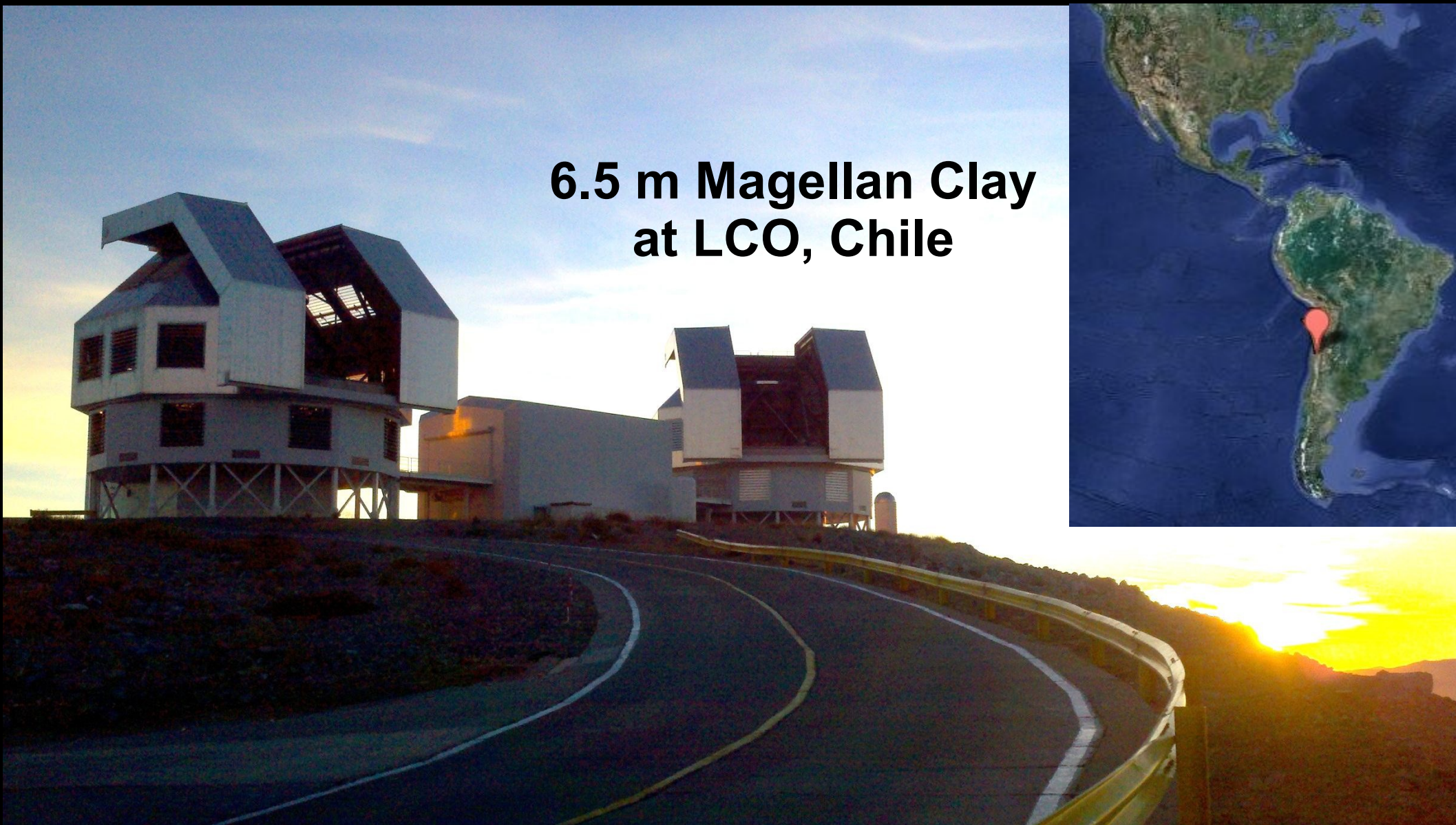
Jared Males

Laird Close, Katie Morzinski, Olivier Guyon

Kate Follette, Alfio Puglisi, Phil Hinz, T.J. Rodigas, Vanessa Bailey, Alycia Weinberger, John Monnier, Volker Toll, Derek Kopon, Ya-Lin Wu

MagAO

**6.5 m Magellan Clay
at LCO, Chile**

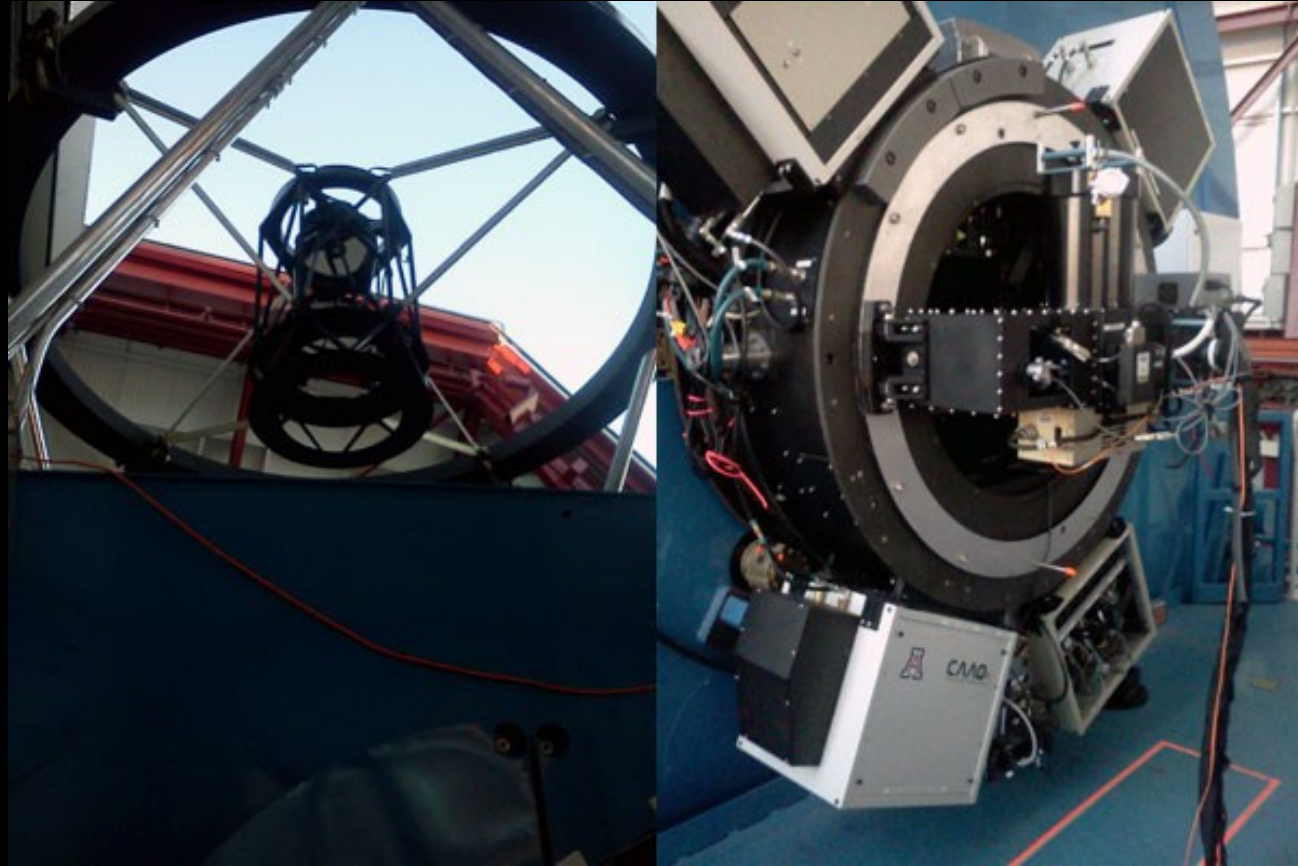
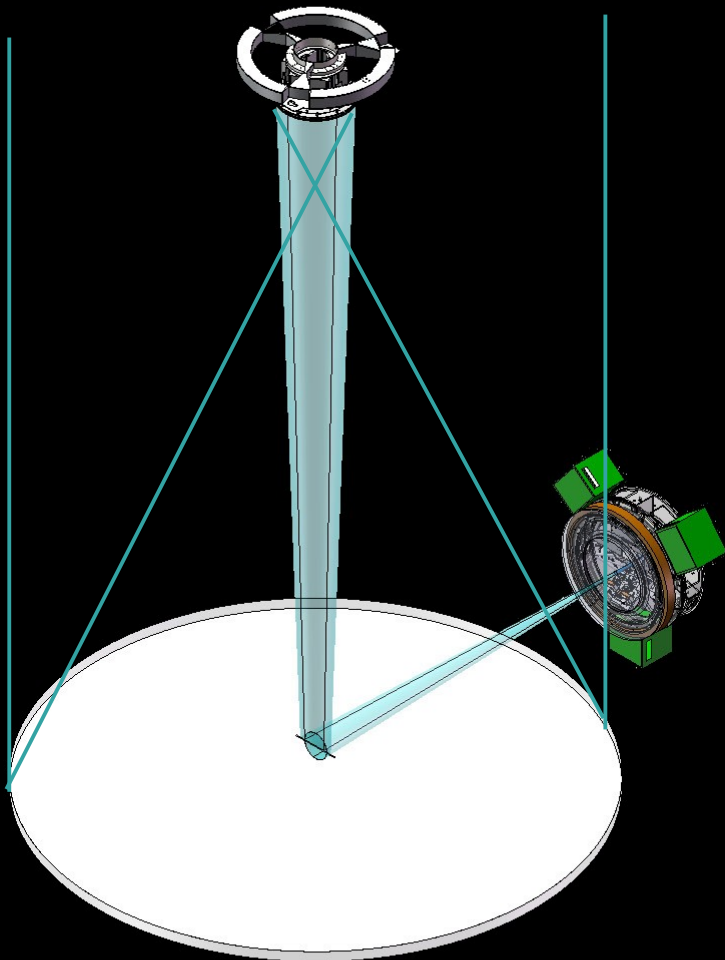


MagAO

you are here



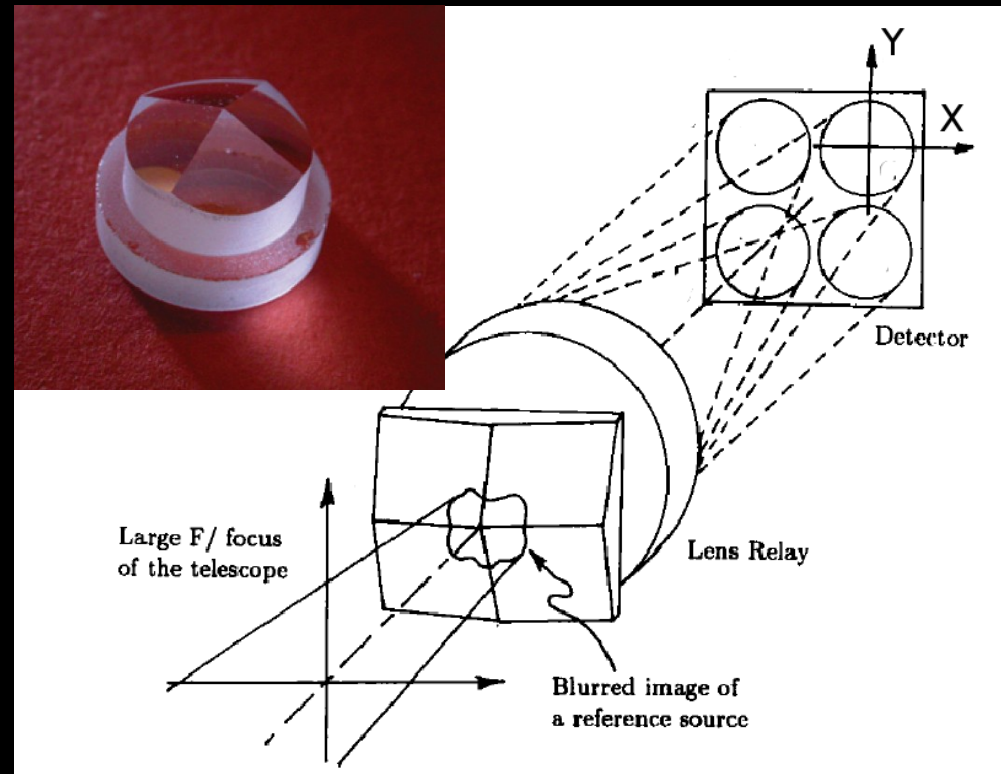
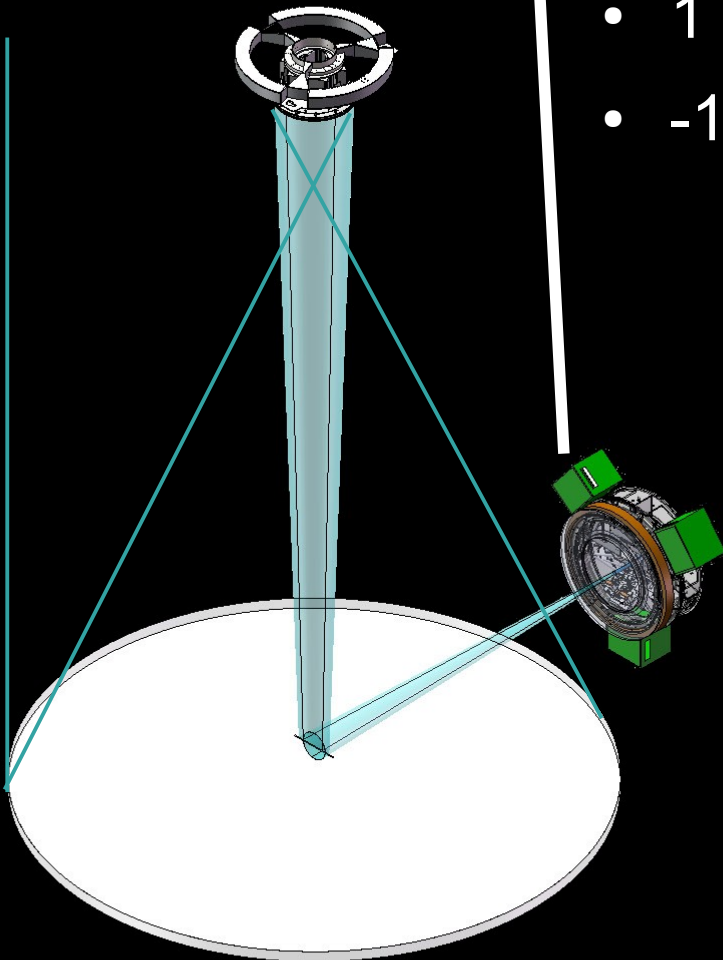
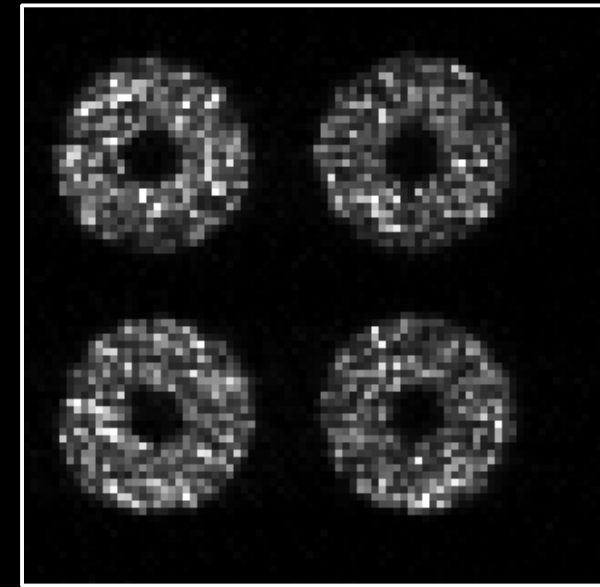
MagAO



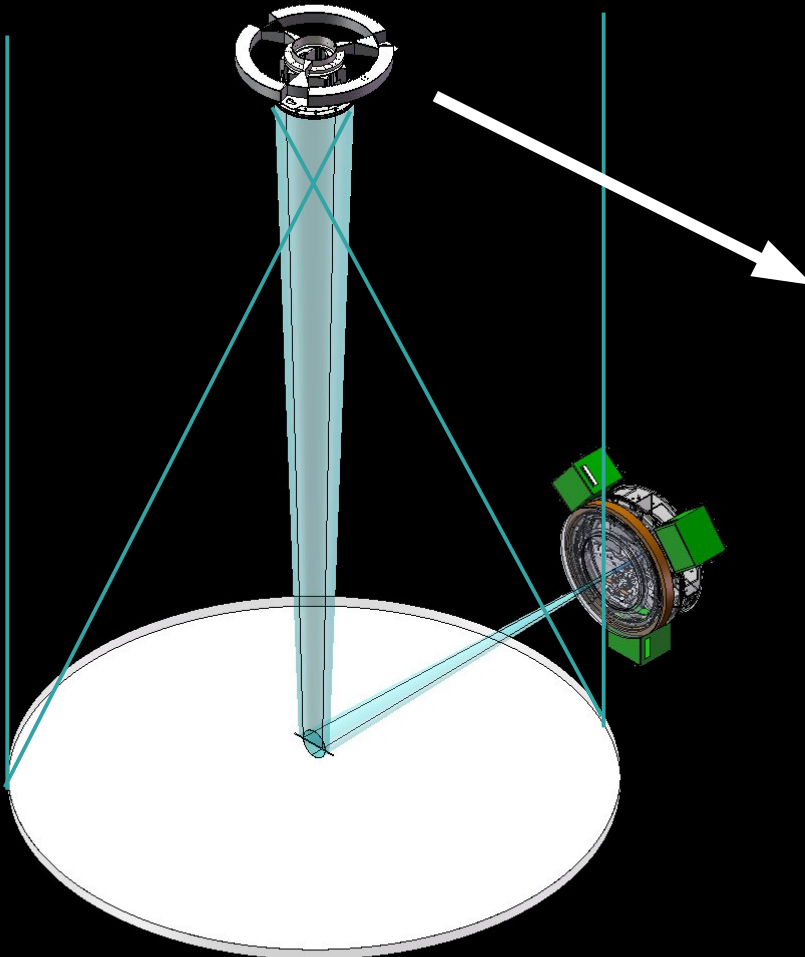
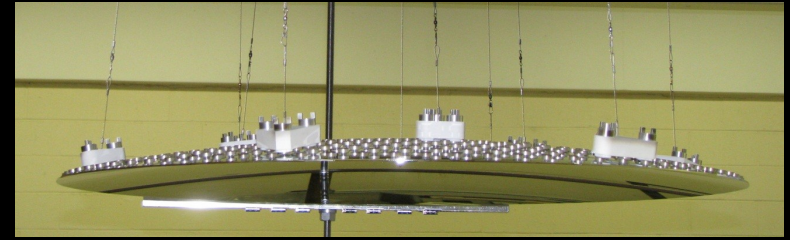
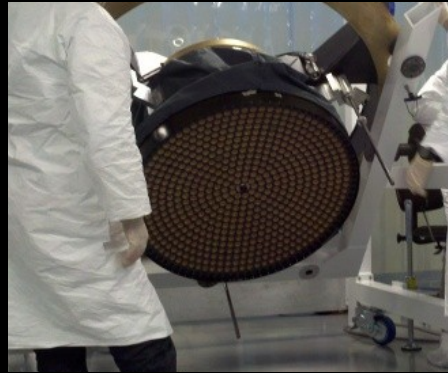
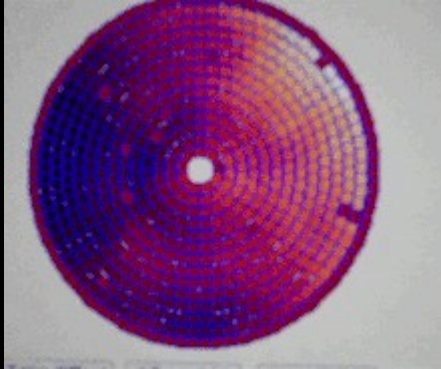
A mutated clone of the LBT AO systems

MagAO

- Pyramid Wavefront Sensor
 - 27x27
 - Modulated
 - 1 kHz – 50 Hz
 - -1.5 to +15.5 mags

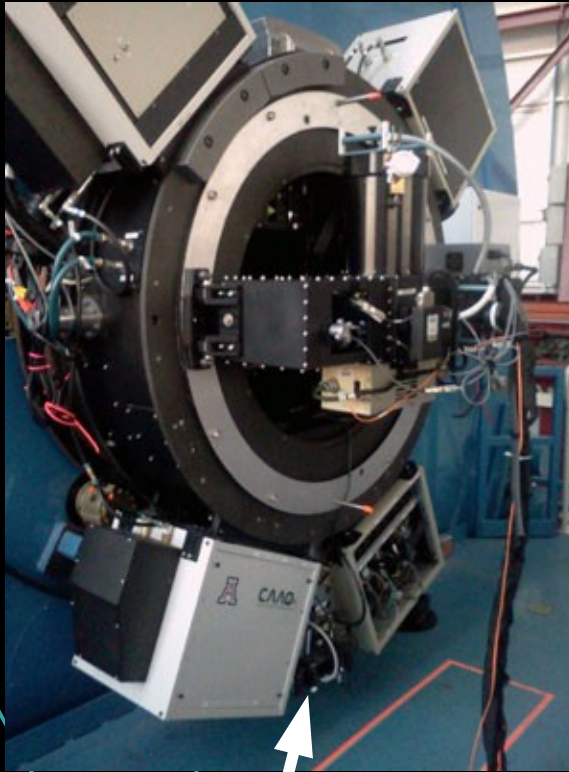


MagAO



- Adaptive Secondary
 - 85 cm diameter
 - 1.6 mm thick
 - 585 actuators
 - 1 kHz response (current)

MagAO



- Instruments

- Clio2: 1.1-5 μm

- PI: Phil Hinz

- Diffraction limited J-M'

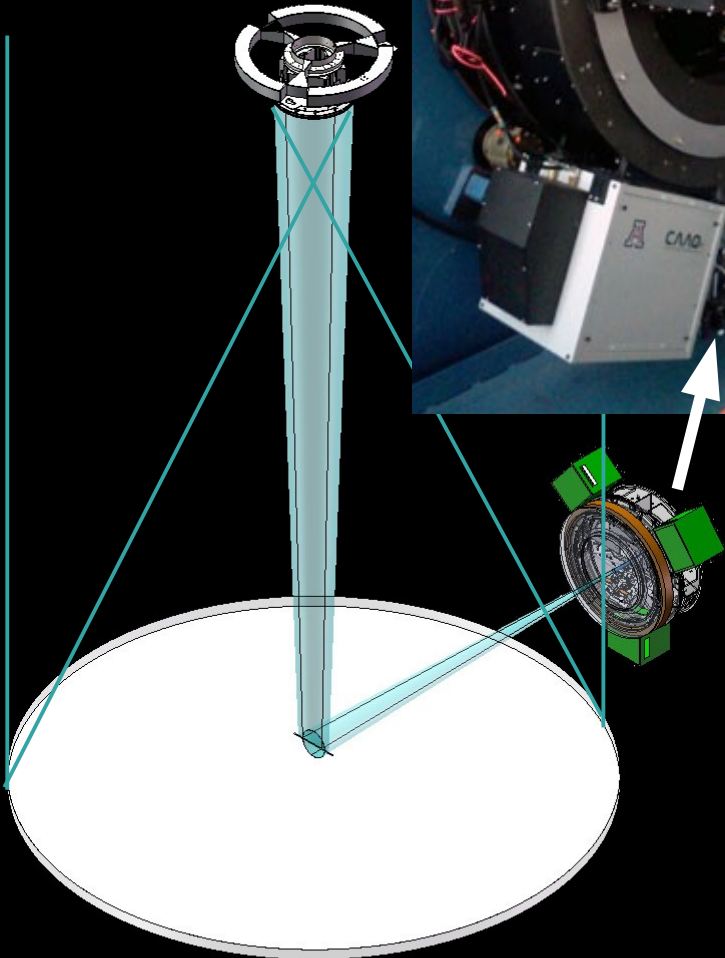
- Prism spectroscopy

- New** - vAPP coronagraphy

- VisAO: 0.6 – 1.1 μm

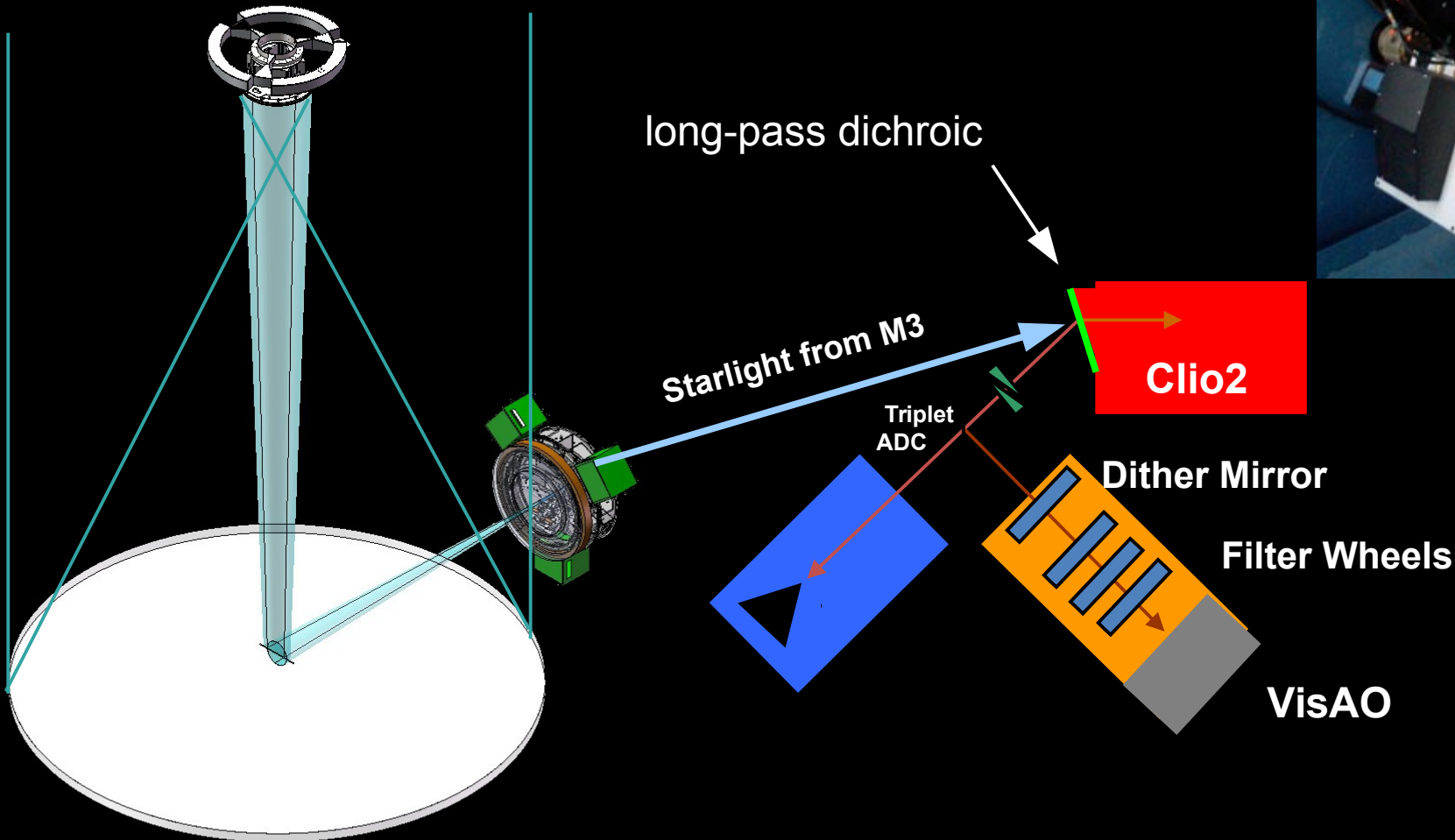
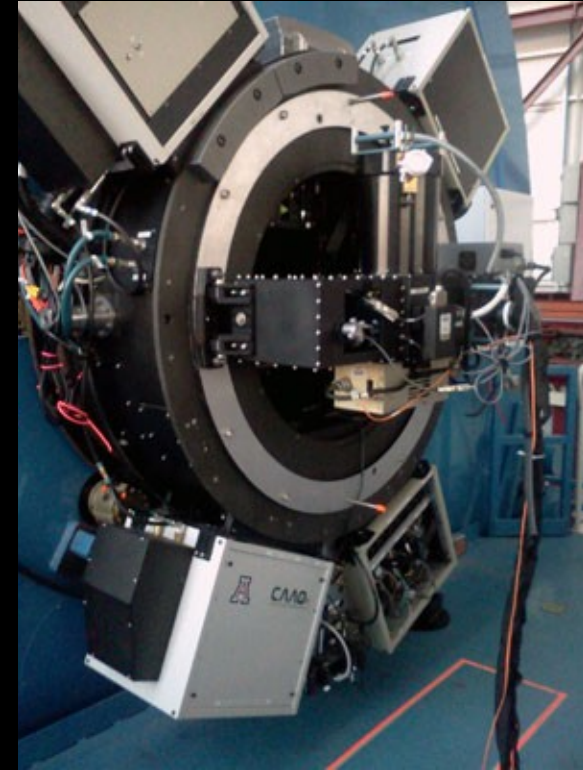
- Diffraction limited r' i' z' Ys

- Spectral Differential Imaging (SDI) at H α and [SII]

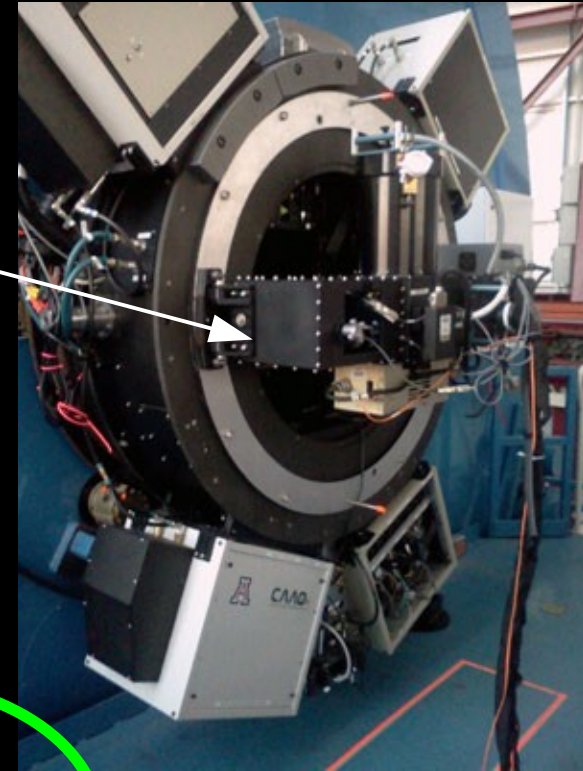
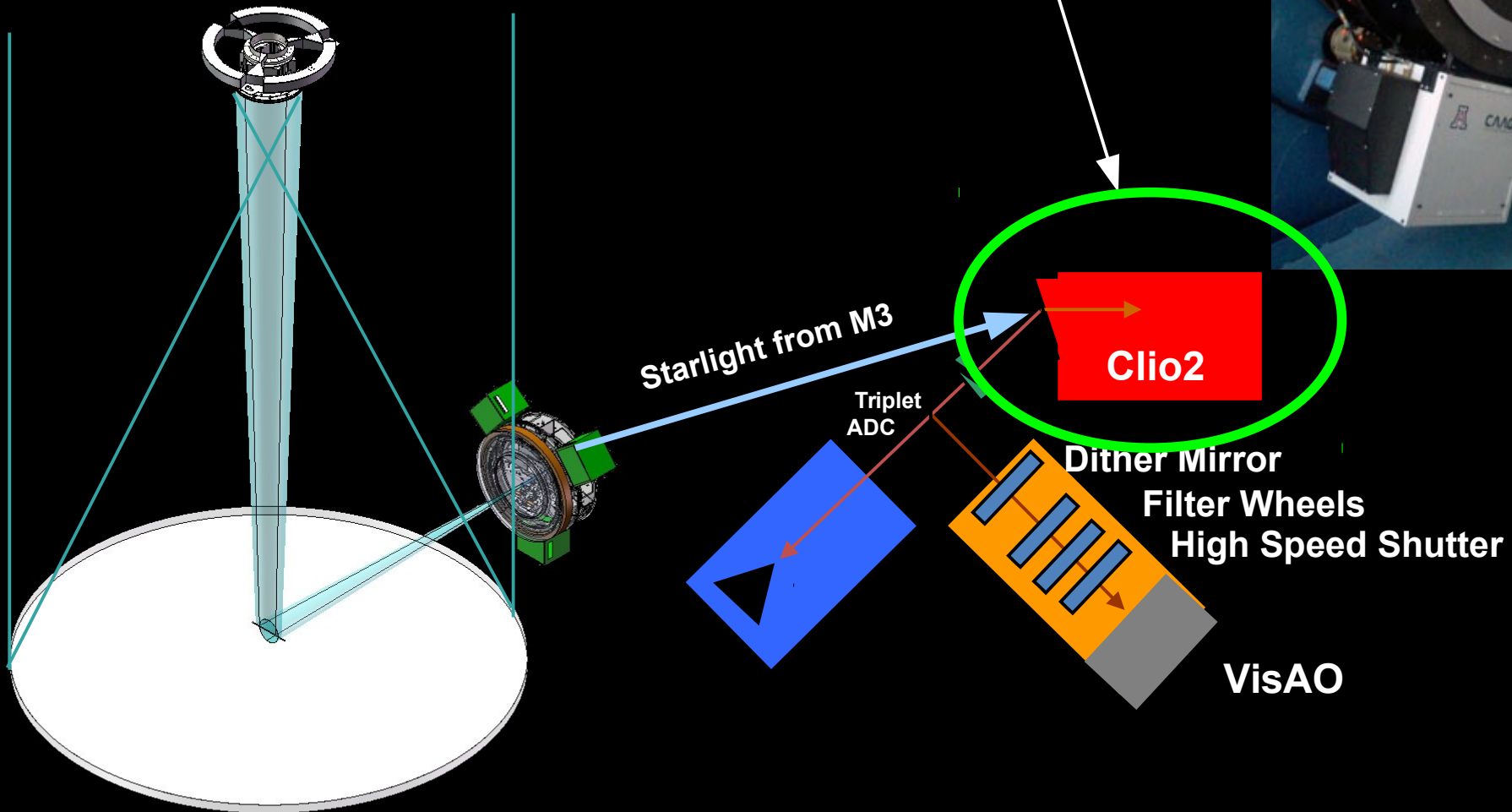


MagAO

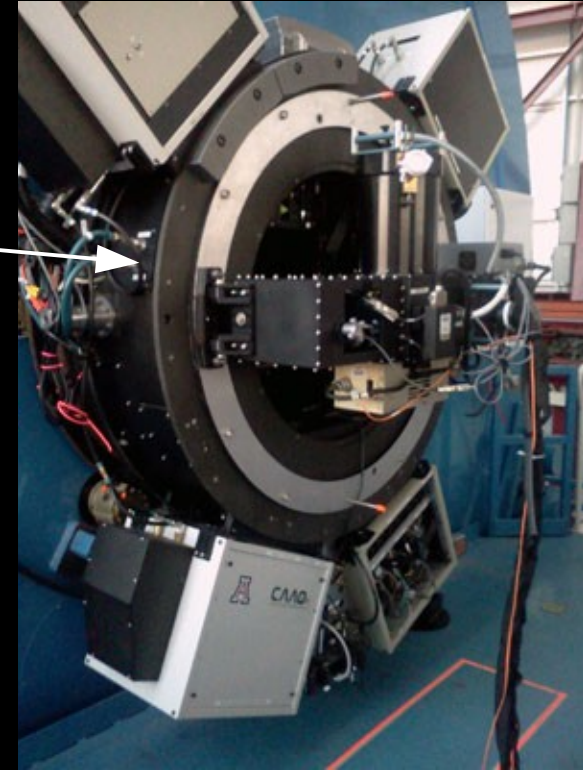
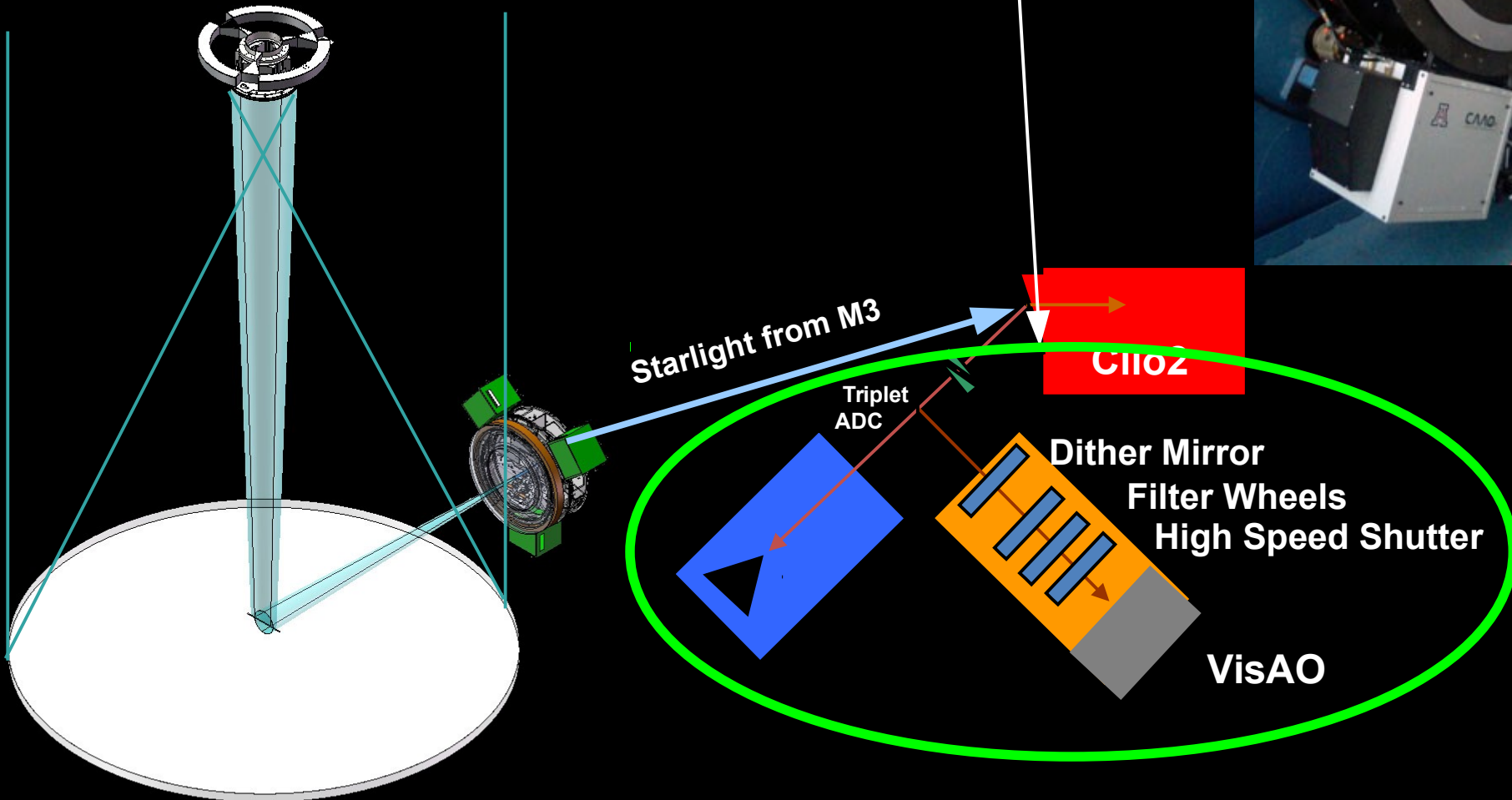
- Simultaneous observing in Vis-IR
- 200% efficient!
 - good for S/N and F.A.R. too . . .



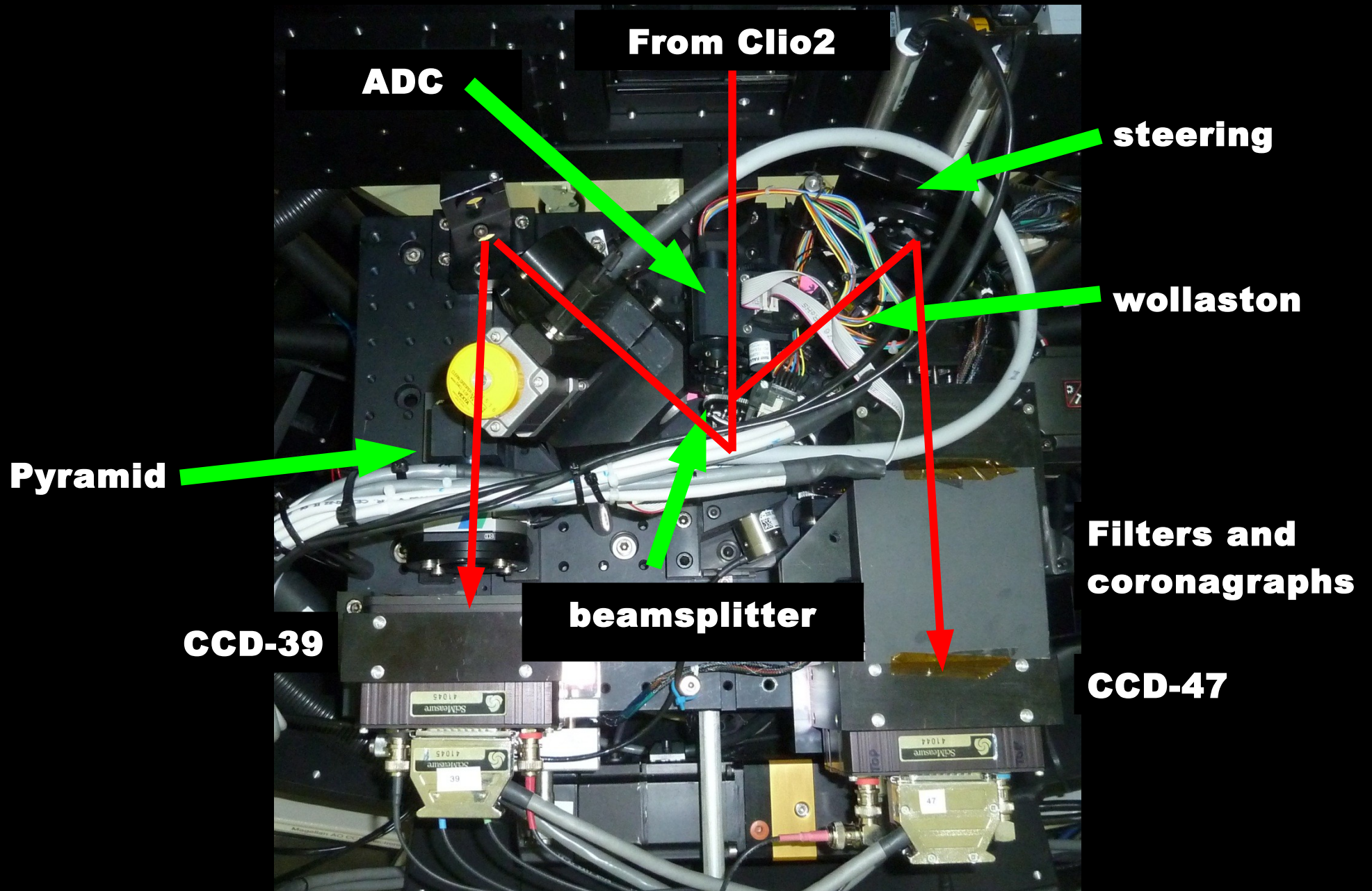
IR Imager: Clio see Katie's talk next



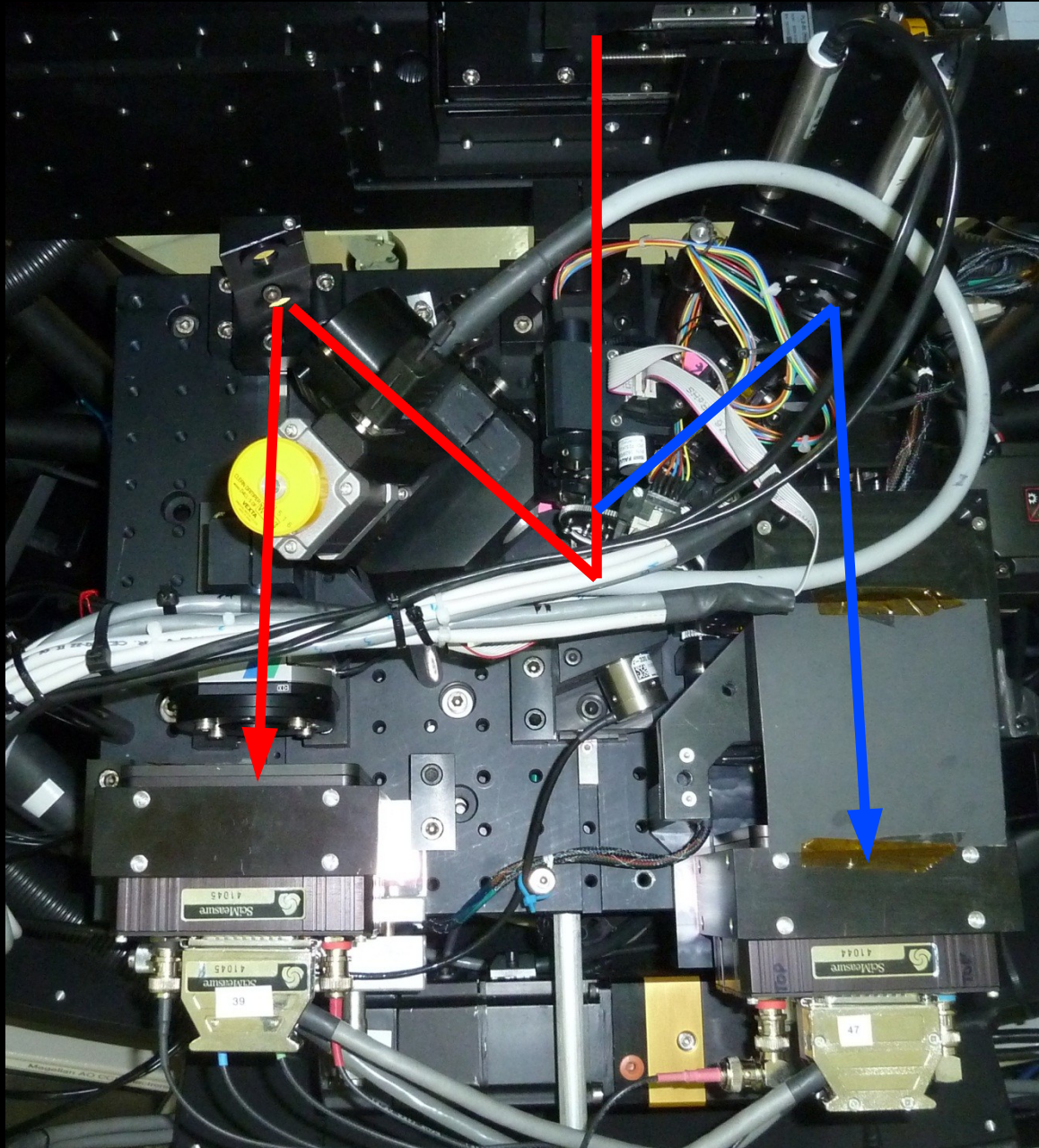
Optical/Visible imaging: VisAO



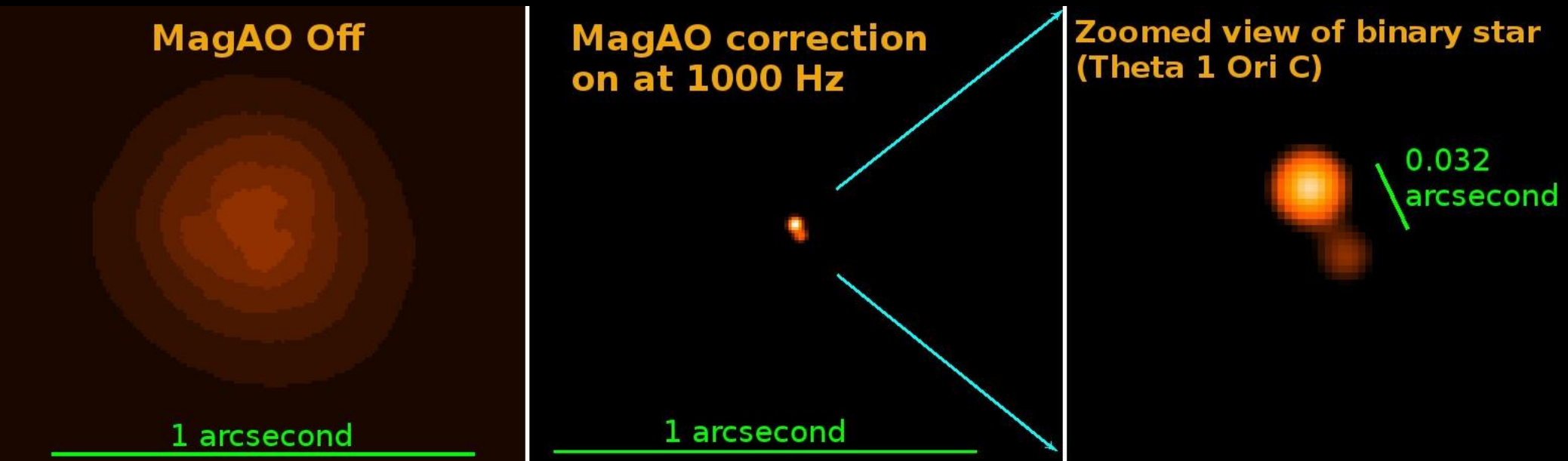
VisAO and the PWFS



VisAO and the PWFS



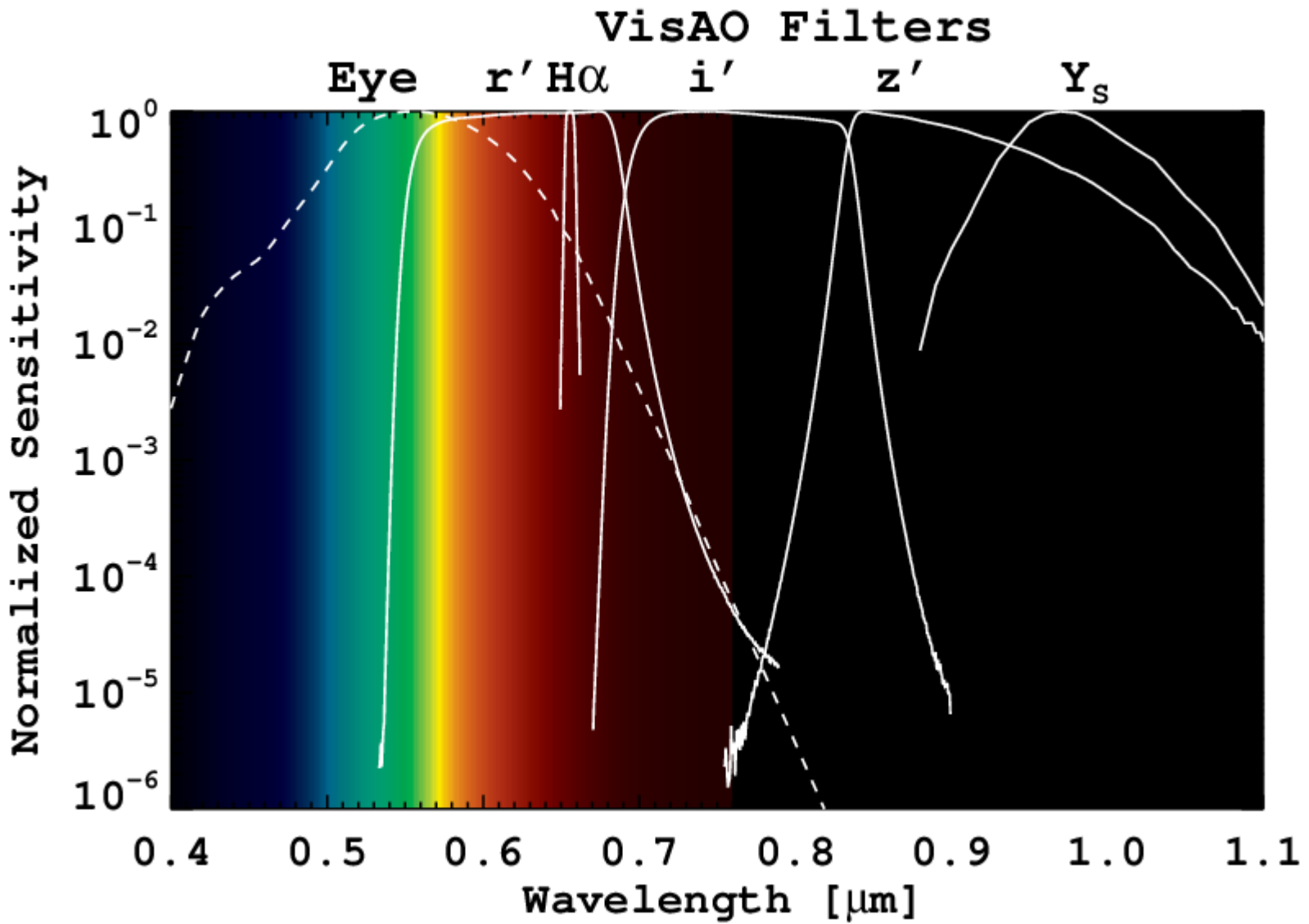
Highest Resolution Imaging

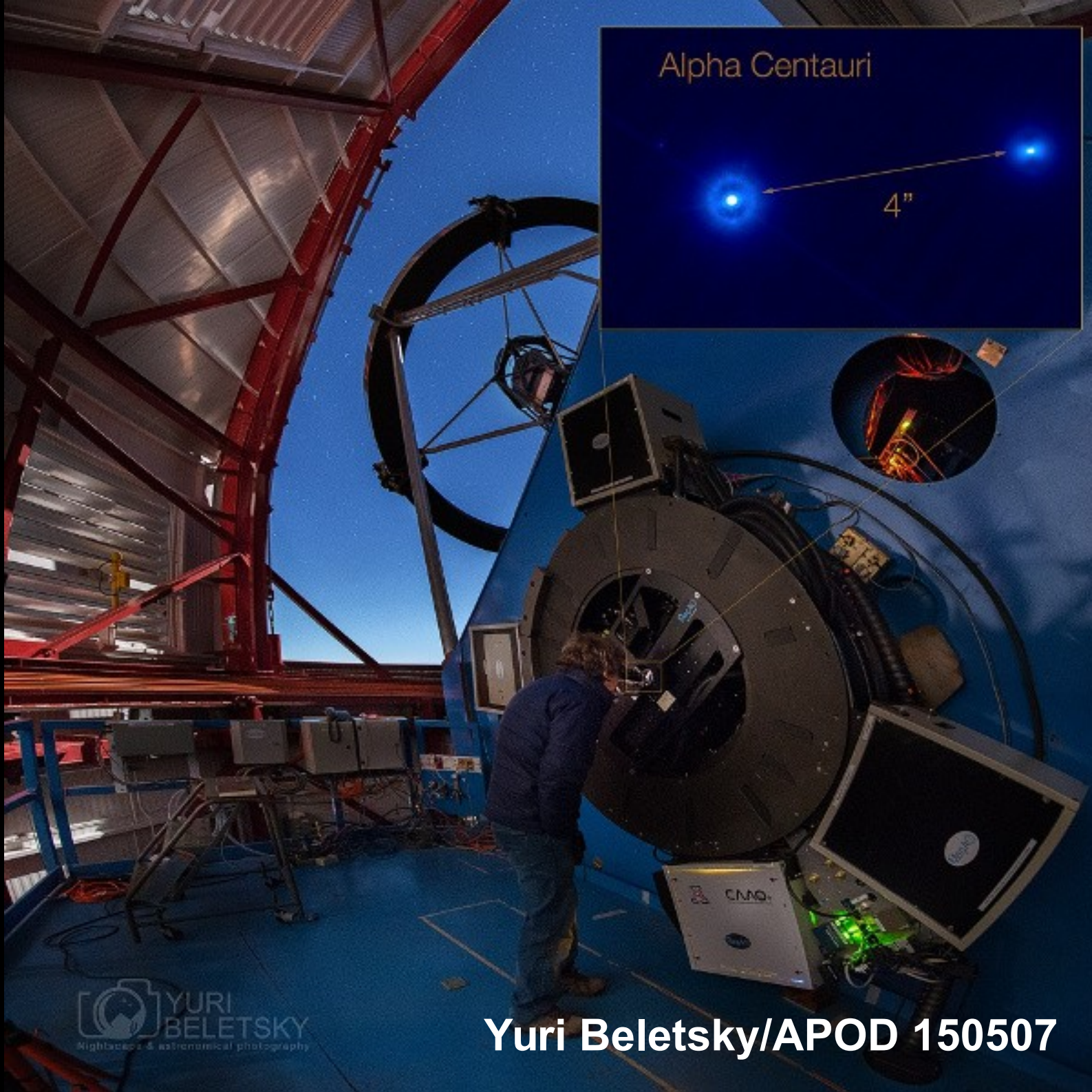


[OI] (630 nm), long exposure, filled-aperture image of θ^1 Ori C.
FWHM = 26 mas

Close et al., ApJ (2013)

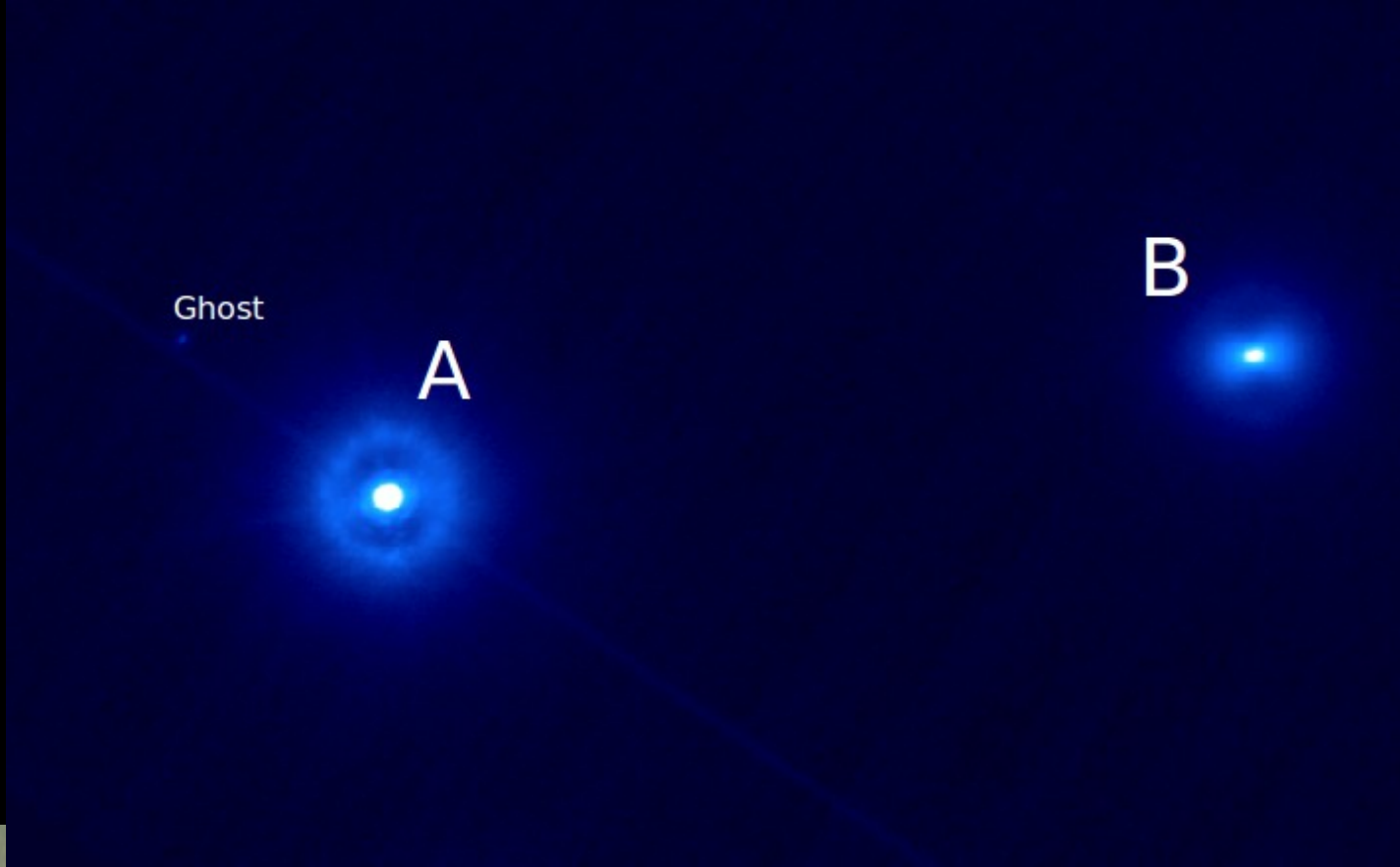
How Visible is VisAO?





Alpha Centauri

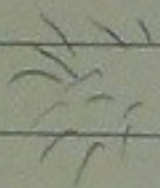
4''



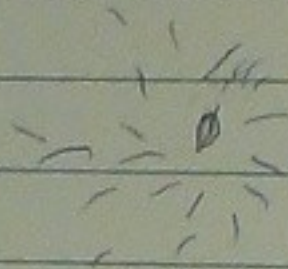
3 May 2015

Katie Morzinski

Alpha Cen



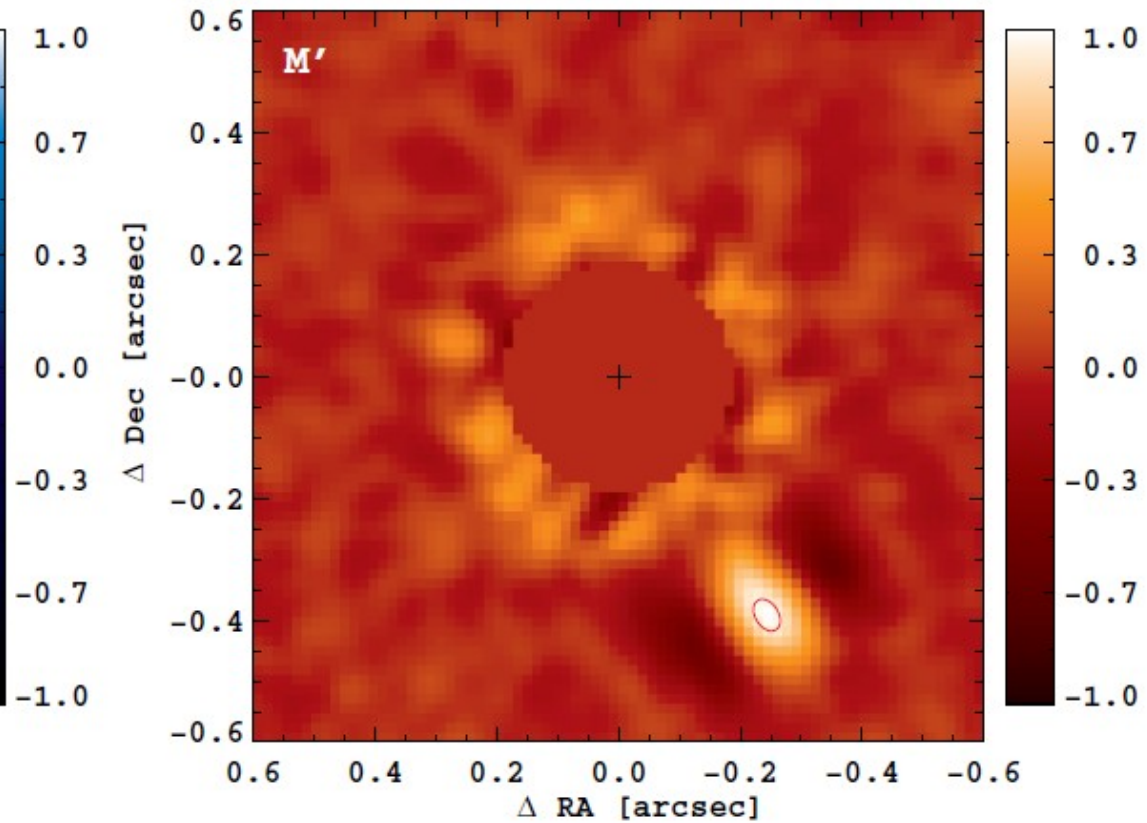
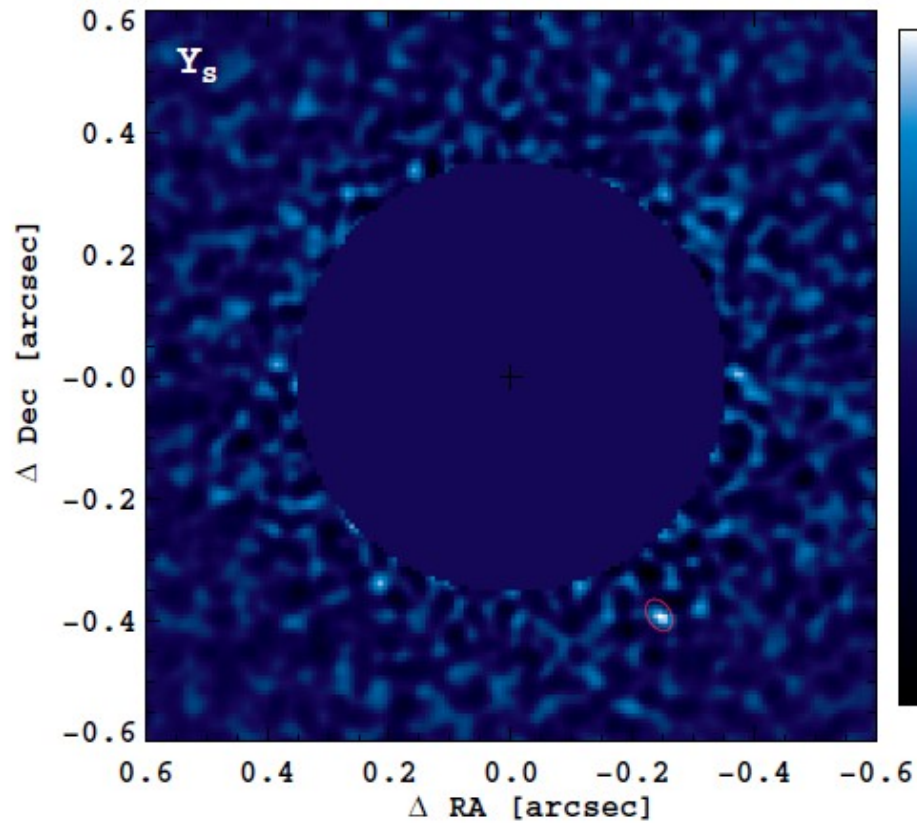
B



A

High Contrast With VisAO

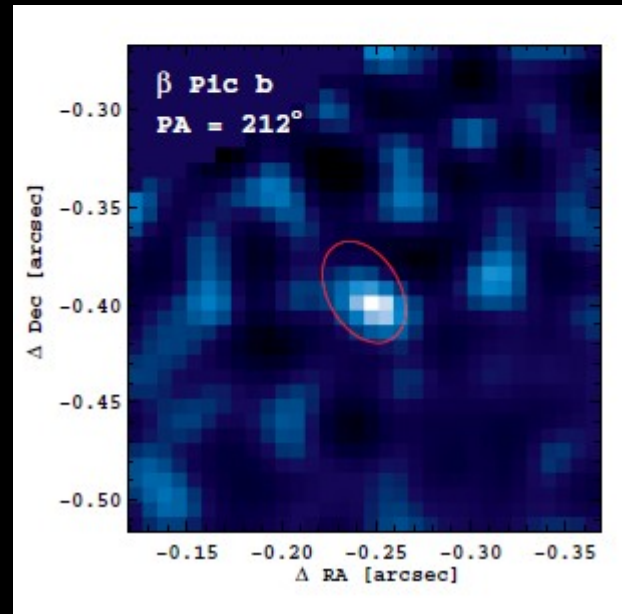
β Pictoris b



Males et al, ApJ, 2014

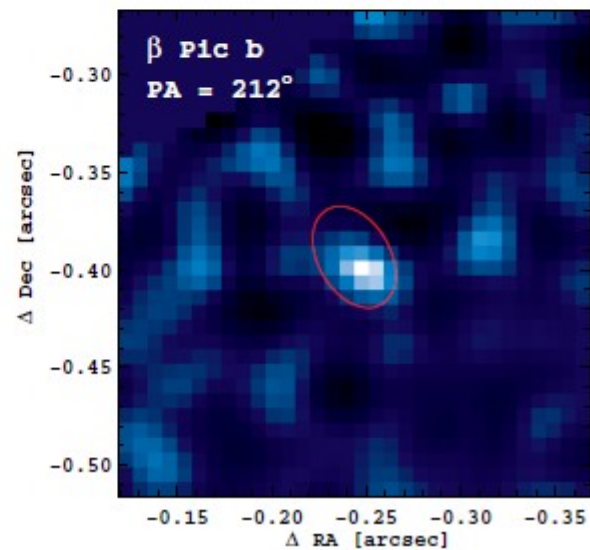
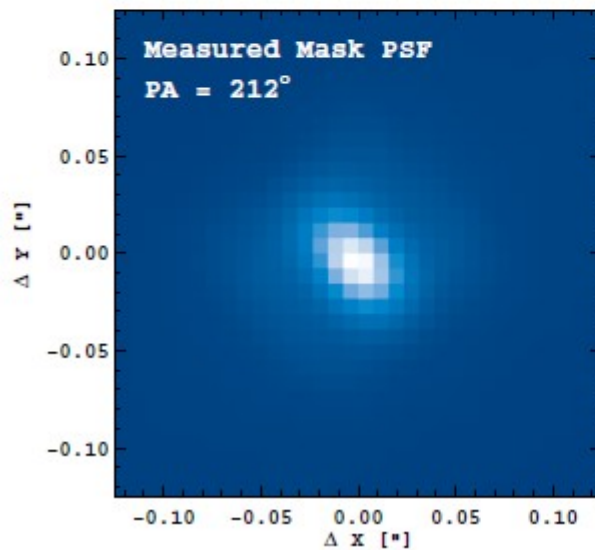
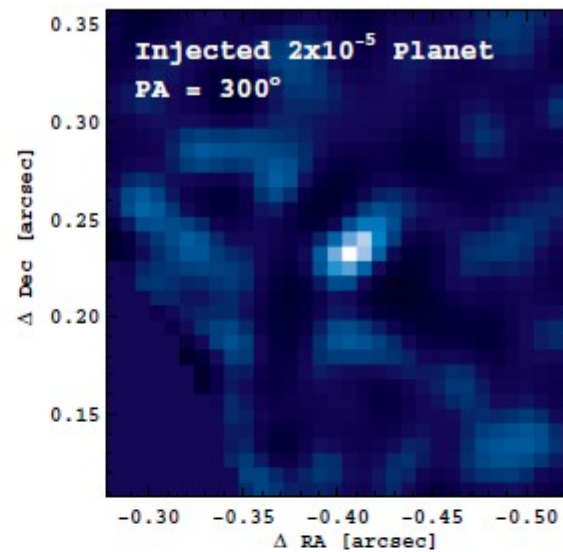
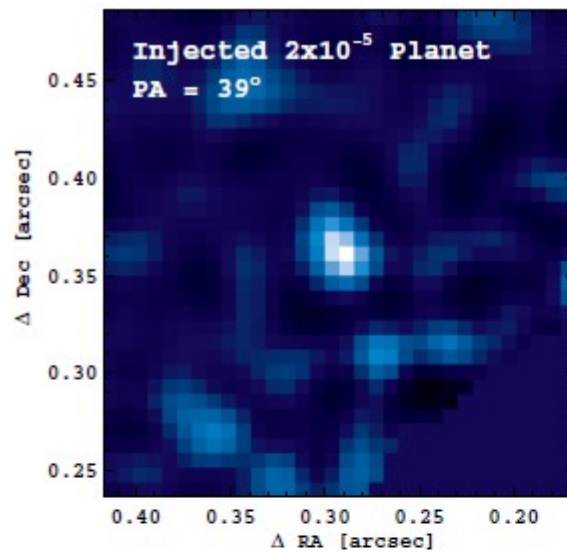
Morzinski et al, in prep

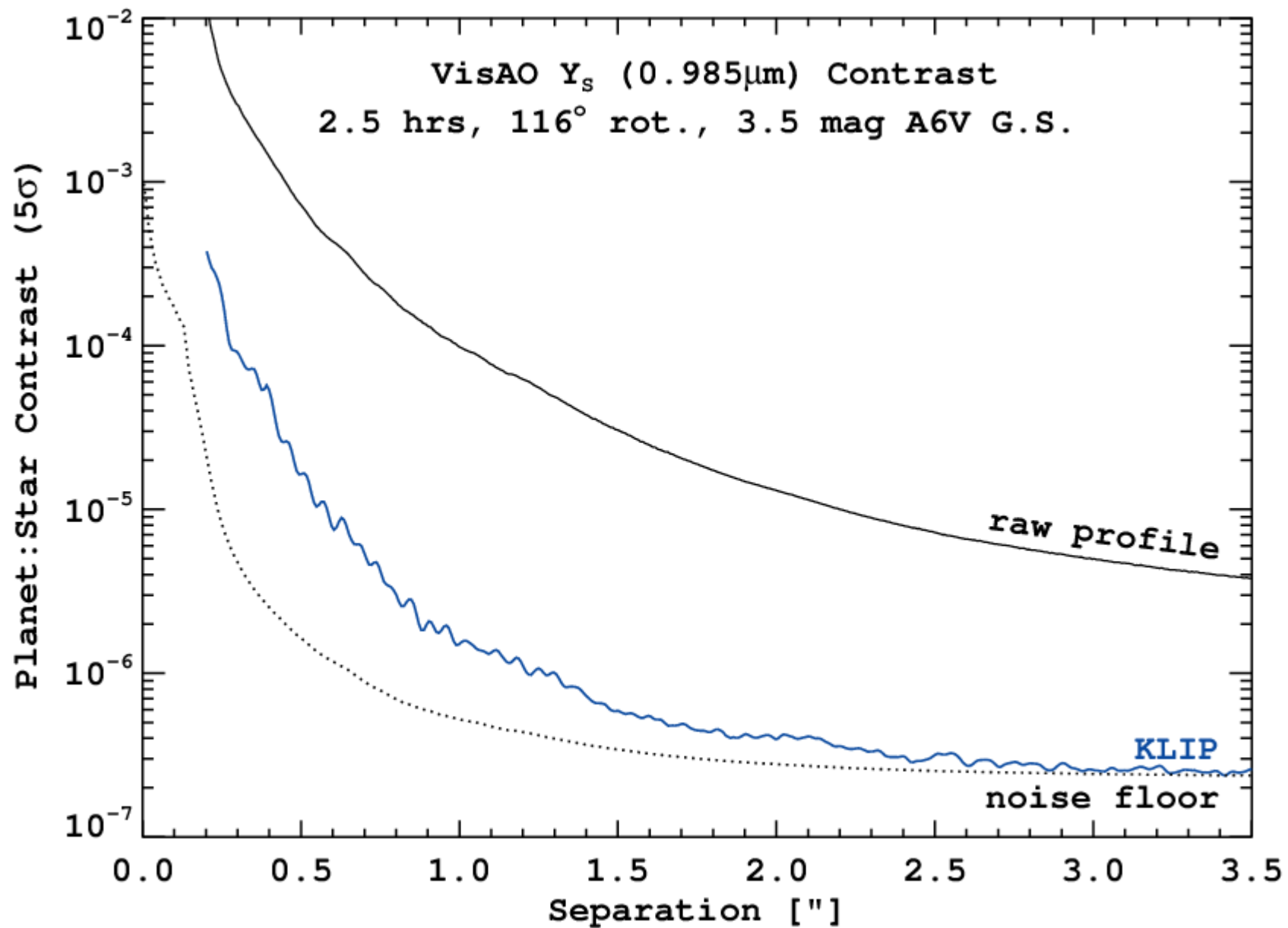
β Pictoris with MagAO

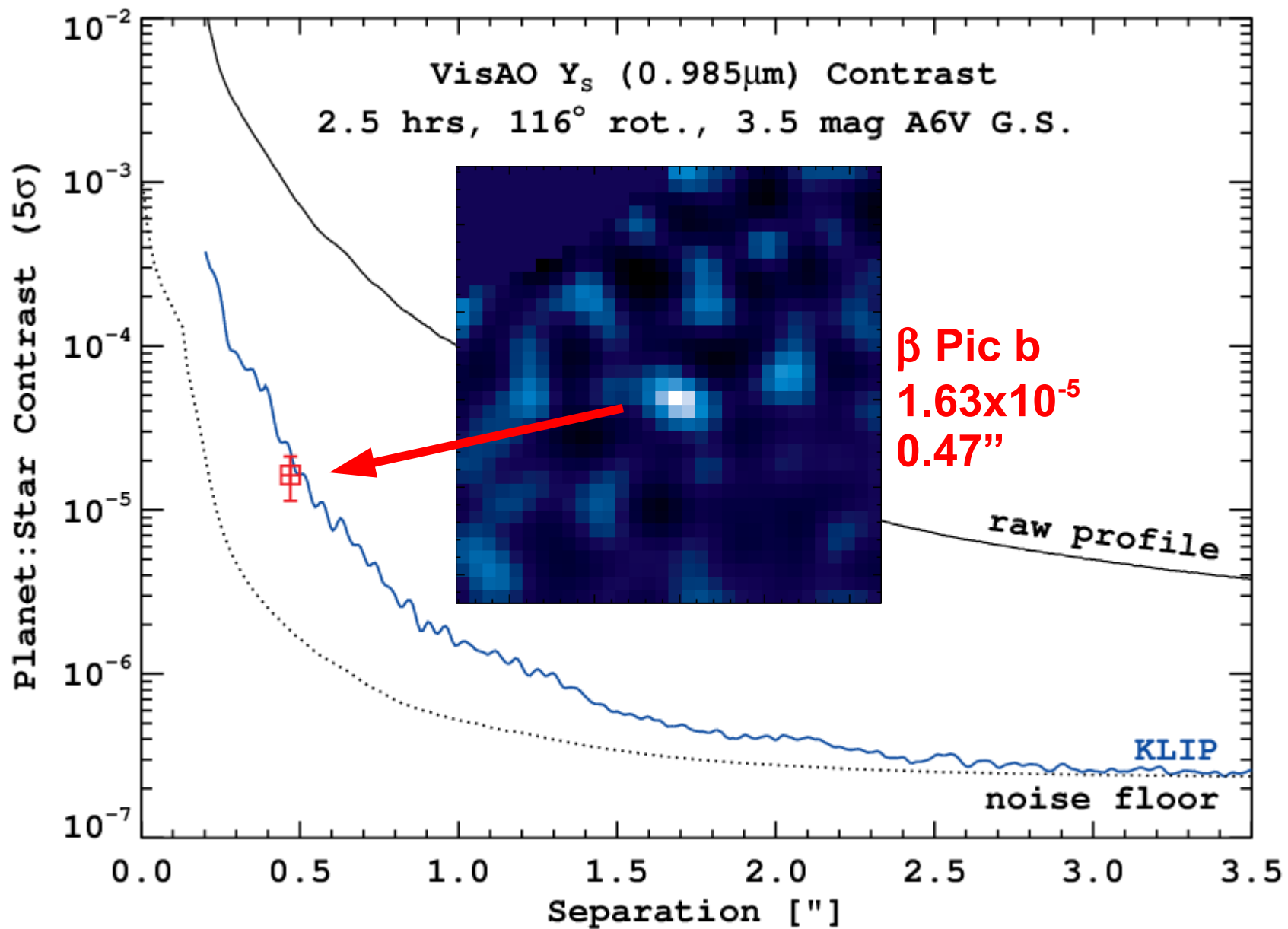


- VisAO @ 0.98 μm (Ys)
 - Red ellipse is Clio2 2σ astrometry
- VisAO S/N = 4.1

Photometric Calibration

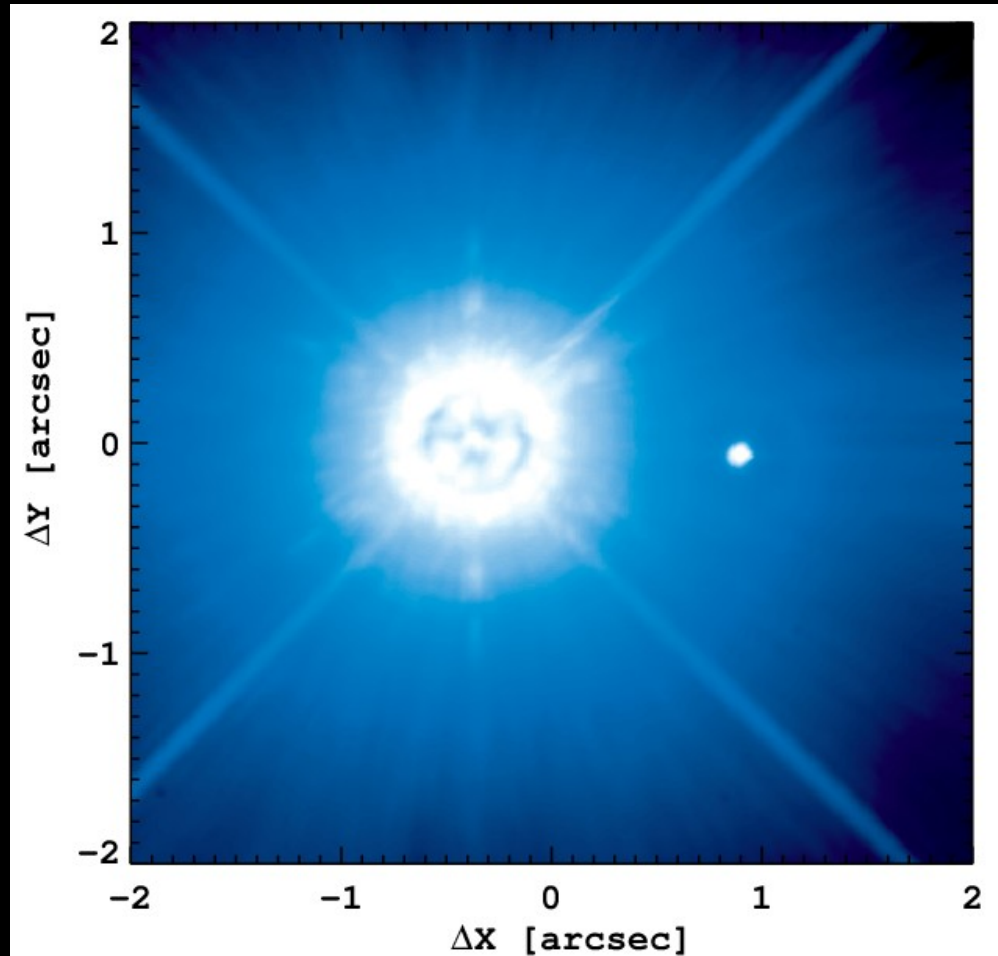
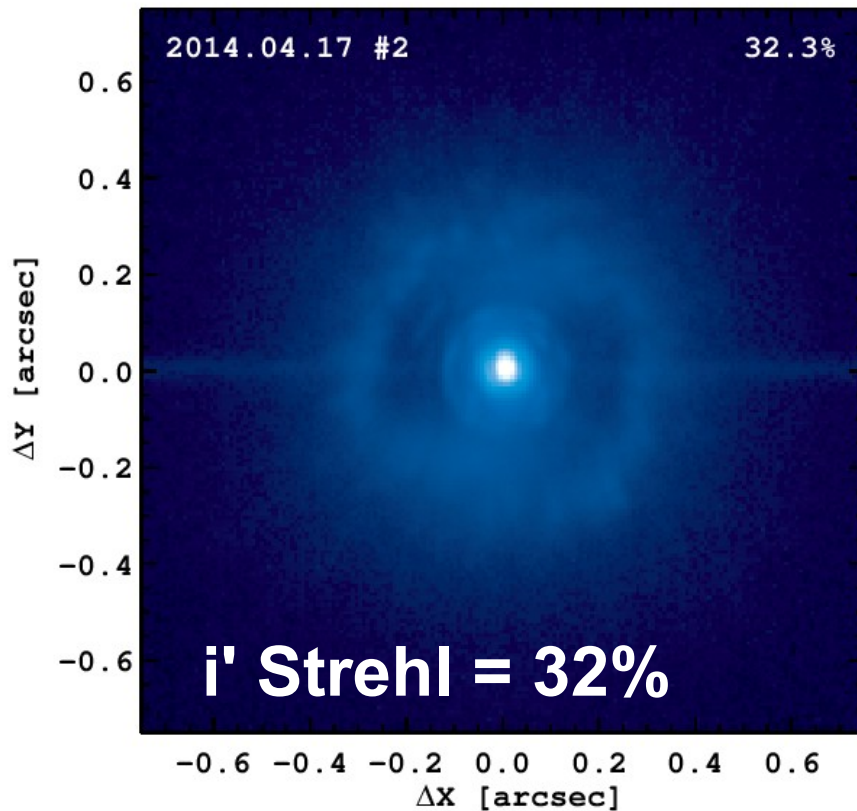




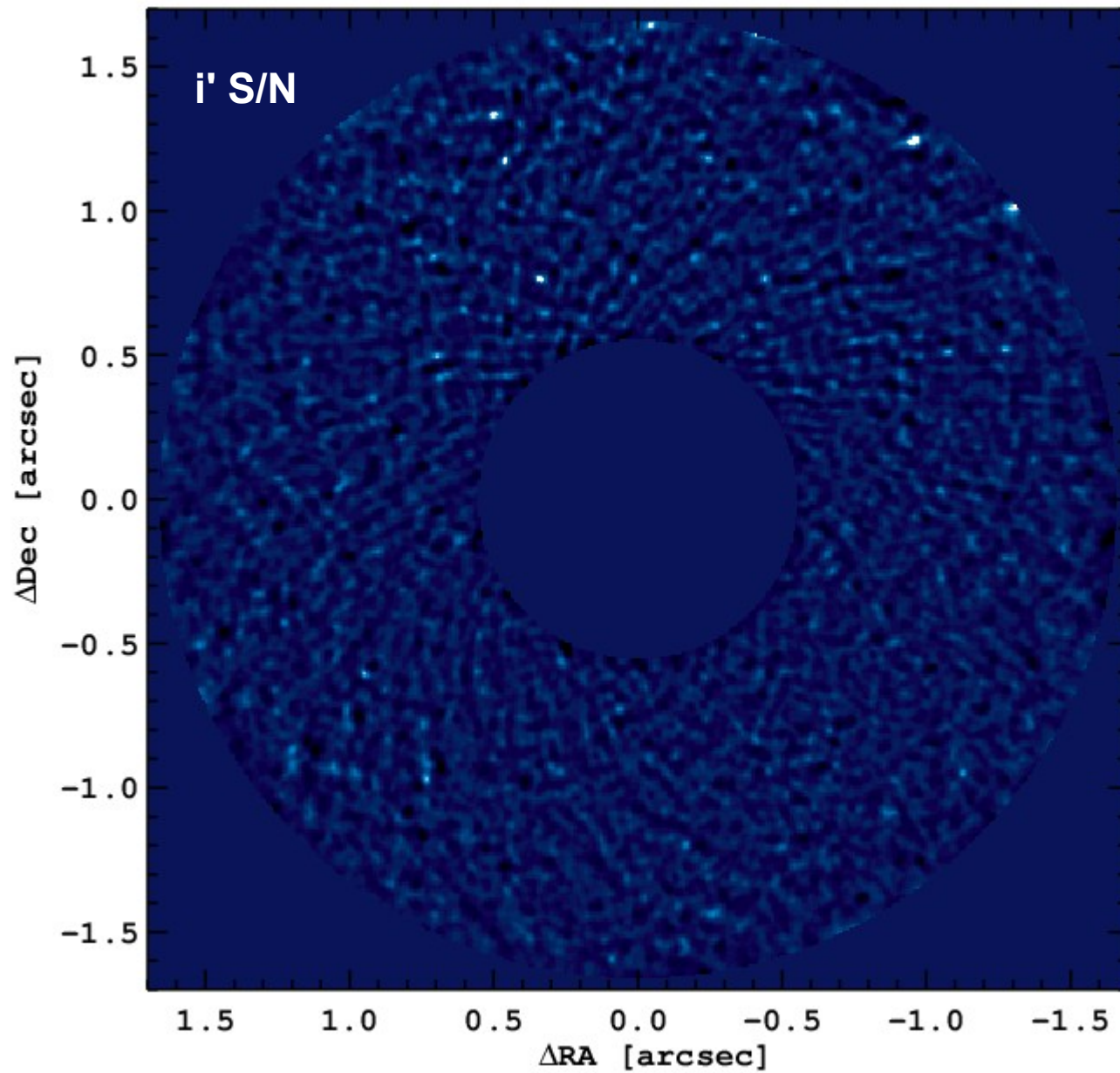


α Cen A with VisAO

- The CCD camera, not the eyepiece
- Able to resolve the HZ ($\sim 0.7''$ to $\sim 1.6''$)

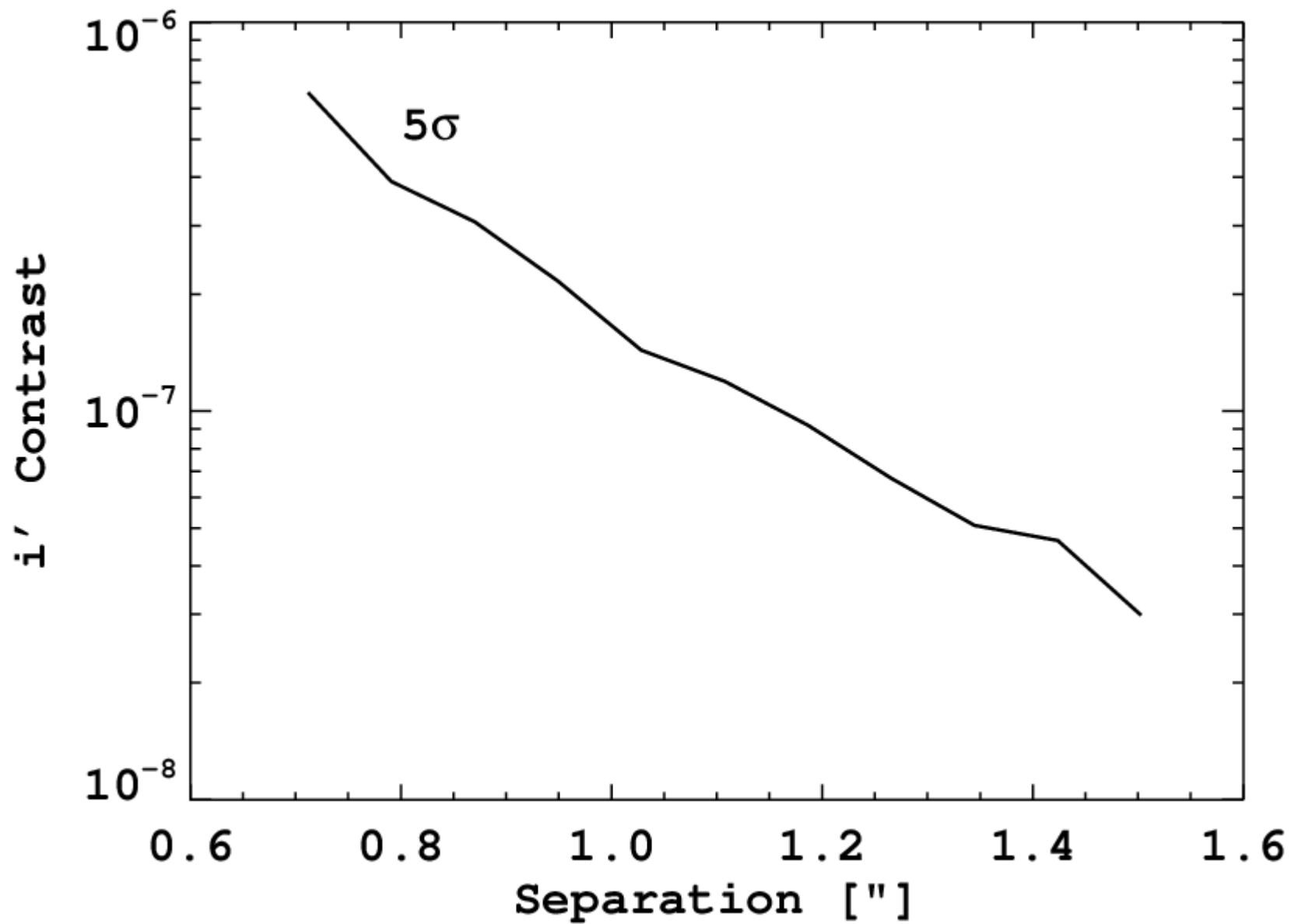


The Nearest G2 HZ

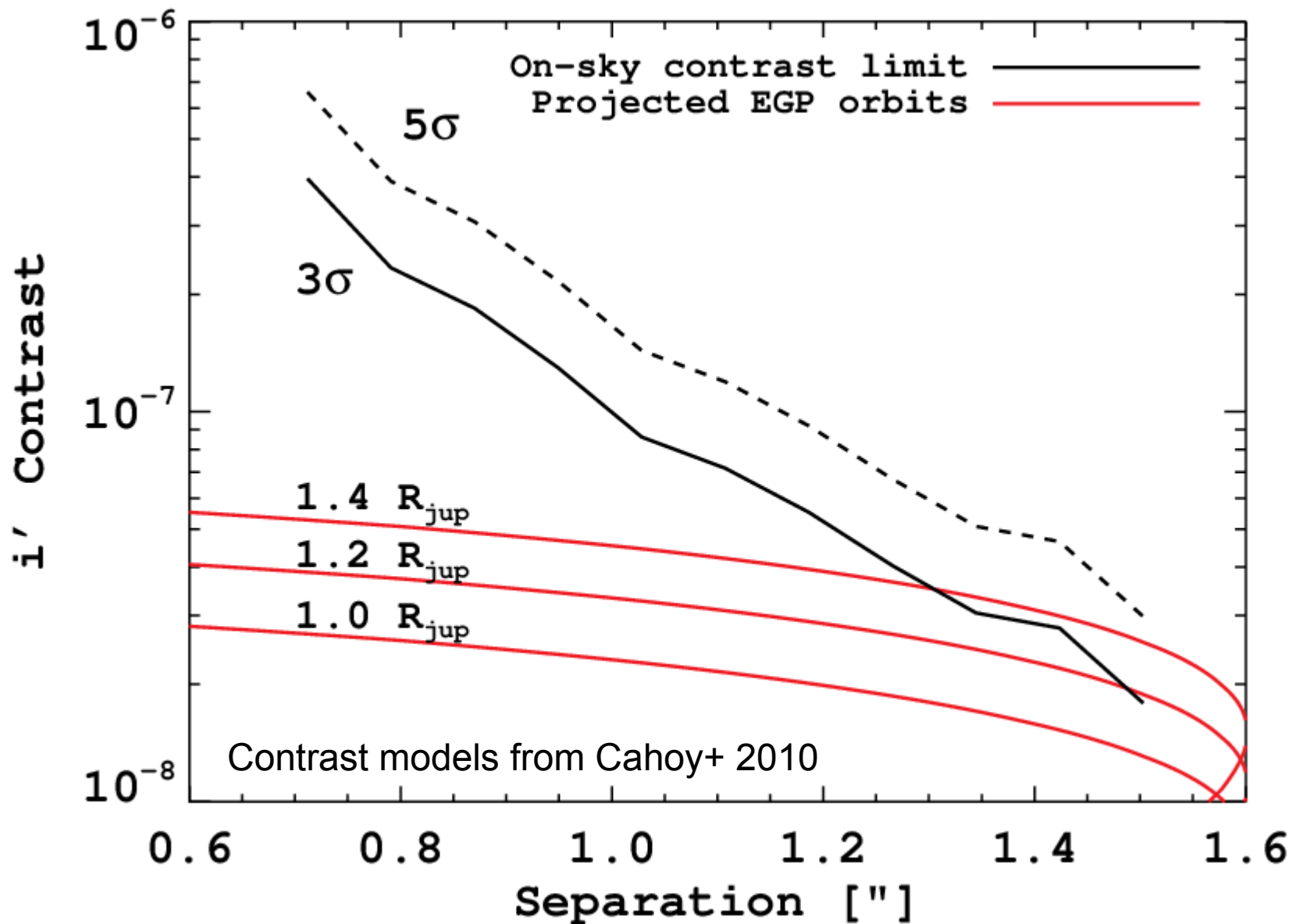


3 Nights Coadded

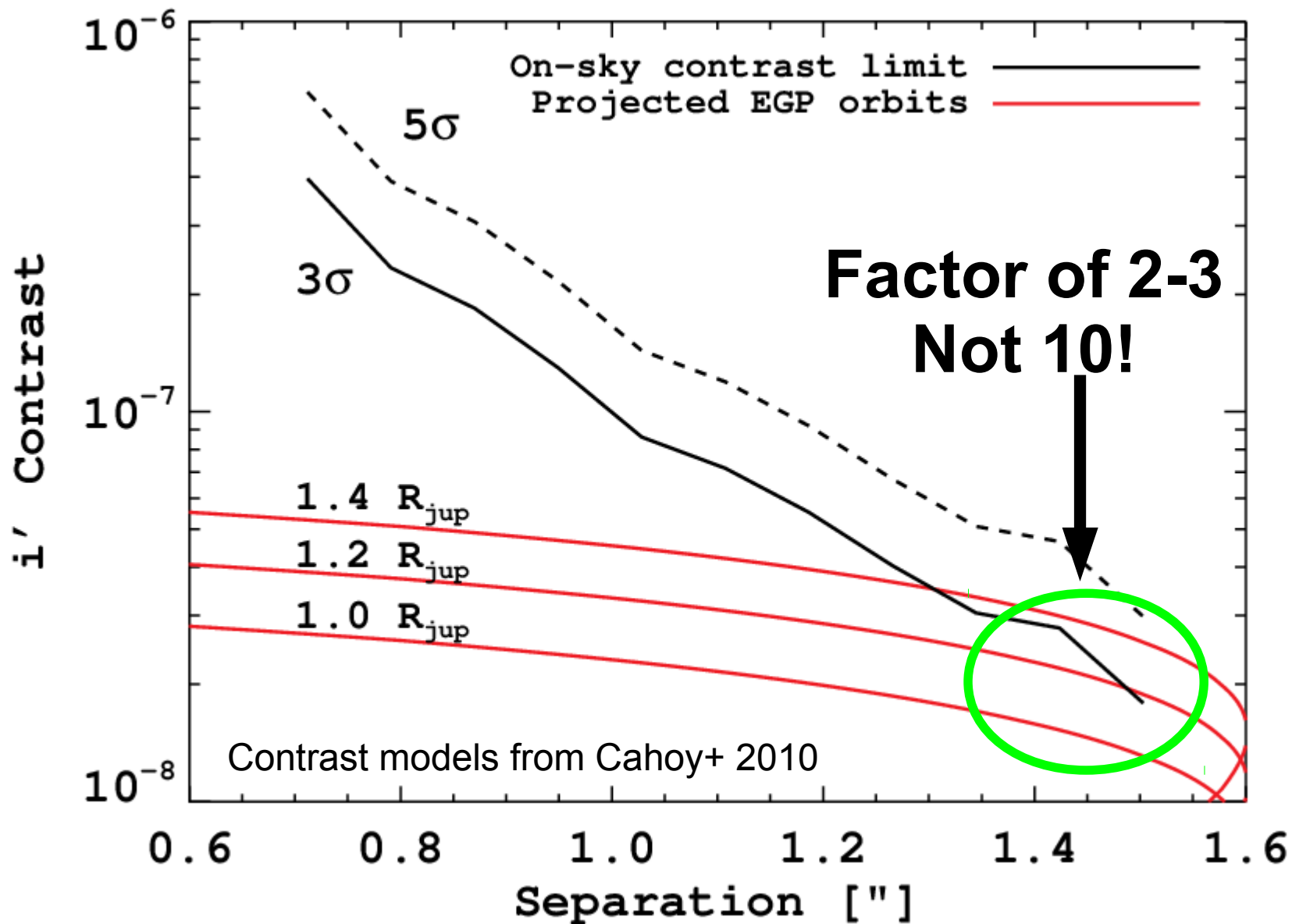
α Cen A Contrast



α Cen A Contrast



α Cen A Contrast



Factor of 2 or 3

- How do we get factors of 2 or 3 (or more) in contrast?
- Upgrade:
 - Go faster – up to 2 kHz
 - Get finer – up to 450 modes
 - Control vibrations – from 8mas to 4 mas rms
- Get Extreme
 - High order "tweeter" AO stage
 - > 3 kHz control loop
 - 1-2 lambda/D coronagraph w/ LOWFS

**MagAO-2K
Upgrade**

**MagAO-X
Concept**

High Contrast at Visible Wavelengths

- MagAO+VisAO:
 - 20-30 mas resolution in the visible
 - $1e-5$ contrast at 0.5" (beta Pic b)
 - Approaching $1e-8$ at 1.5" (alpha Cen HZ)
- We're on our way to the HZ
 - Improvements to existing MagAO
 - Extreme-AO & coronagraph in the visible

For More Info:

jrmale@email.arizona.edu
<http://visao.as.arizona.edu>

MagA 