SCExAO: the Subaru Coronagraphic Extreme AO Project

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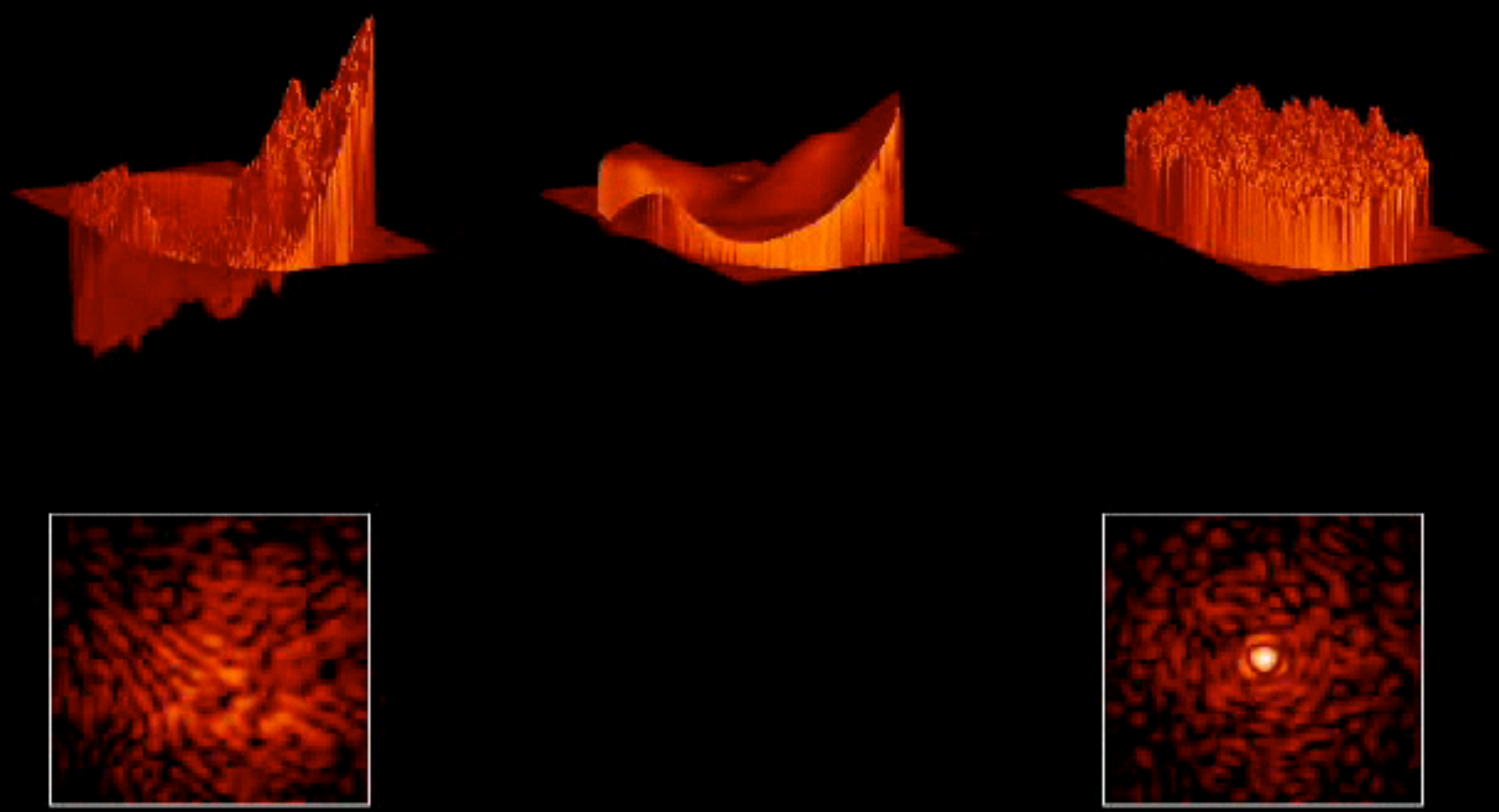
Adaptive Optics: required but not sufficient!



AO stabilizes the wavefront but cannot do a perfect job

You are at best left with *static or slowly varying* aberrations that set contrast detection limits

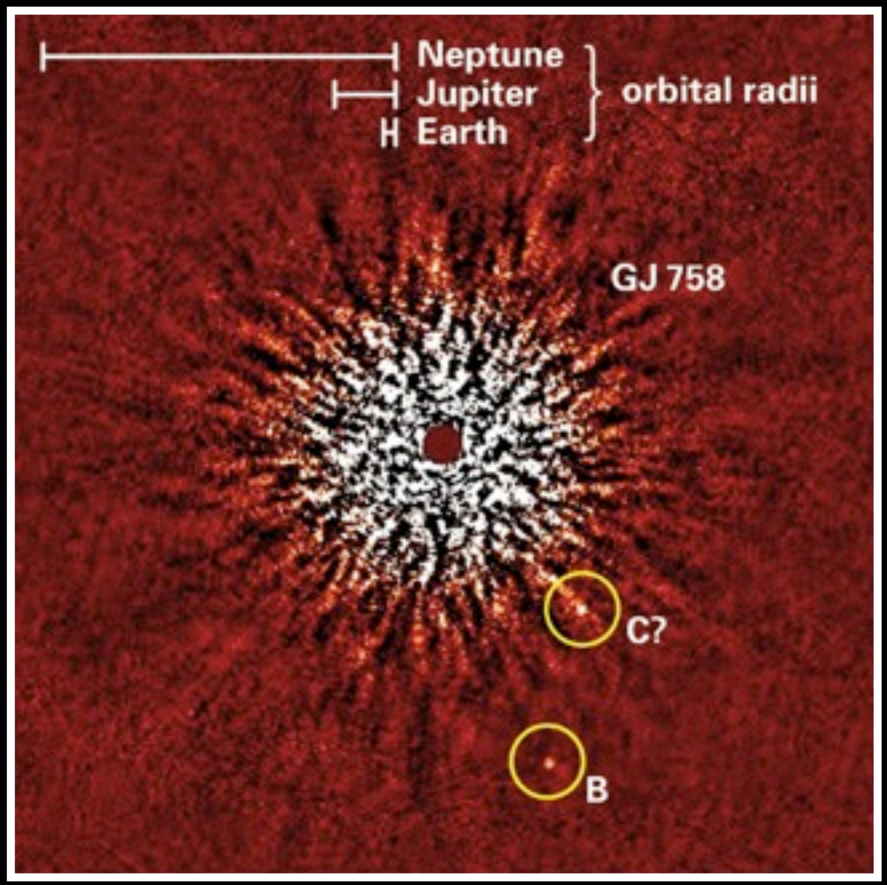
simulation by James P. Lloyd

Take care of an ill-posed problem

$I = O \otimes PSF$

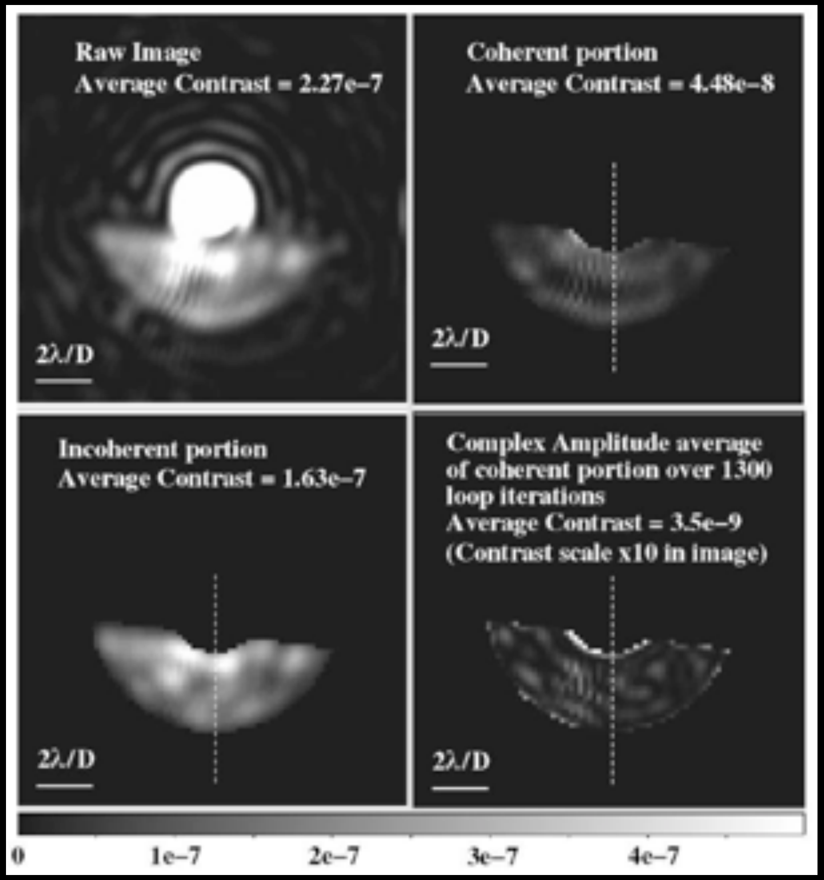
Eliminate the PSF out of the equation

the ADI way...



Marois et al, 2006, ApJ, 641, 556

the exAO way...

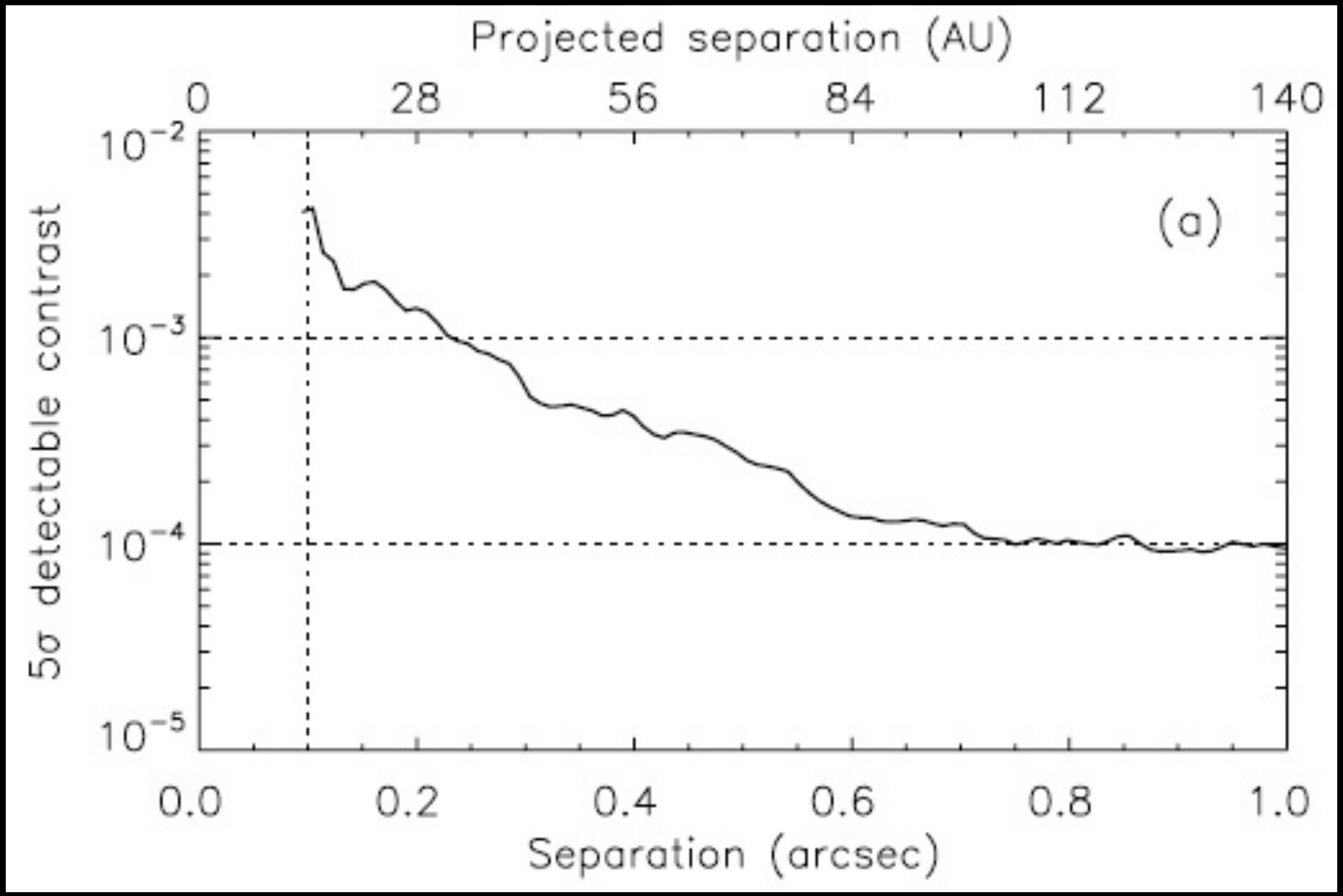


Guyon et al, 2009, PASP, 122, 71

SCExAO

Angular Differential Imaging

The "state of the art": optimized Angular Differential Imaging called LOCI

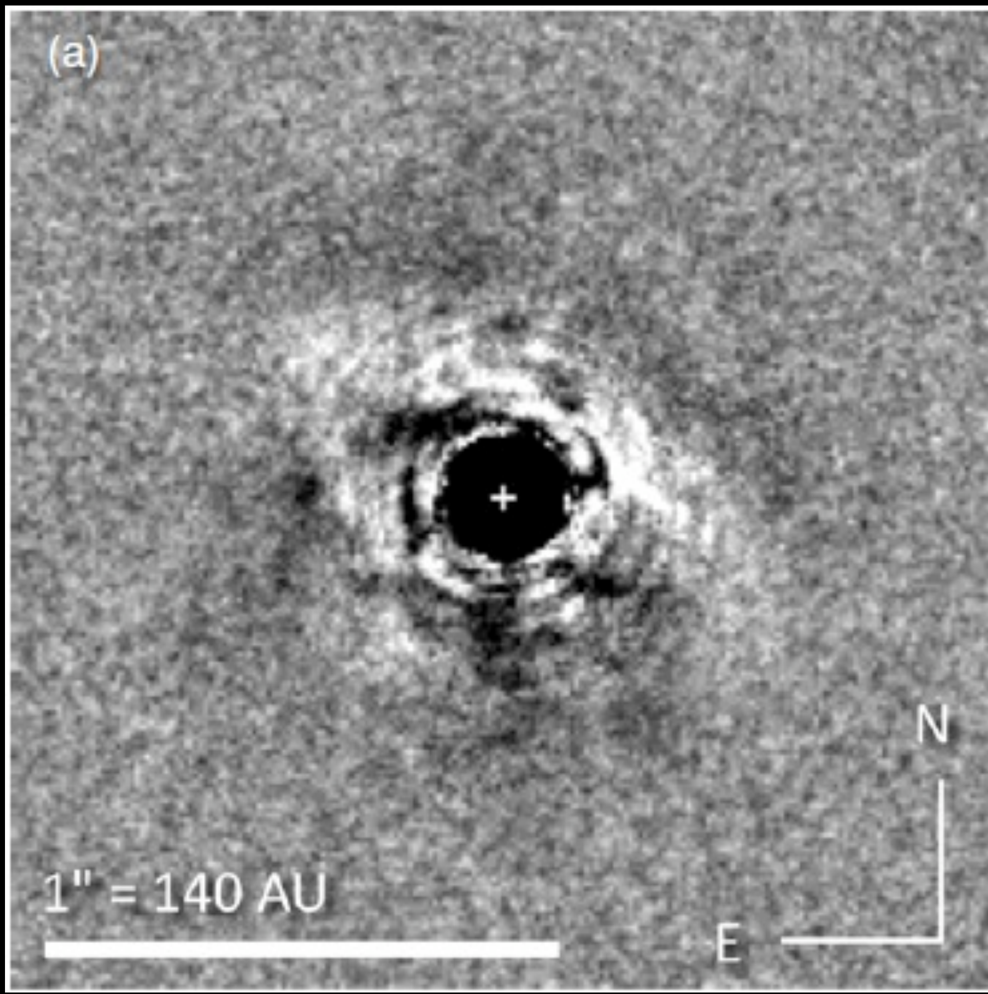


LOCI led to the obtention of direct images of sub-stellar companions around HR 8799, GJ 758, etc.

Remarkable... but reaches peak performance somewhere around 0.5 arcsec

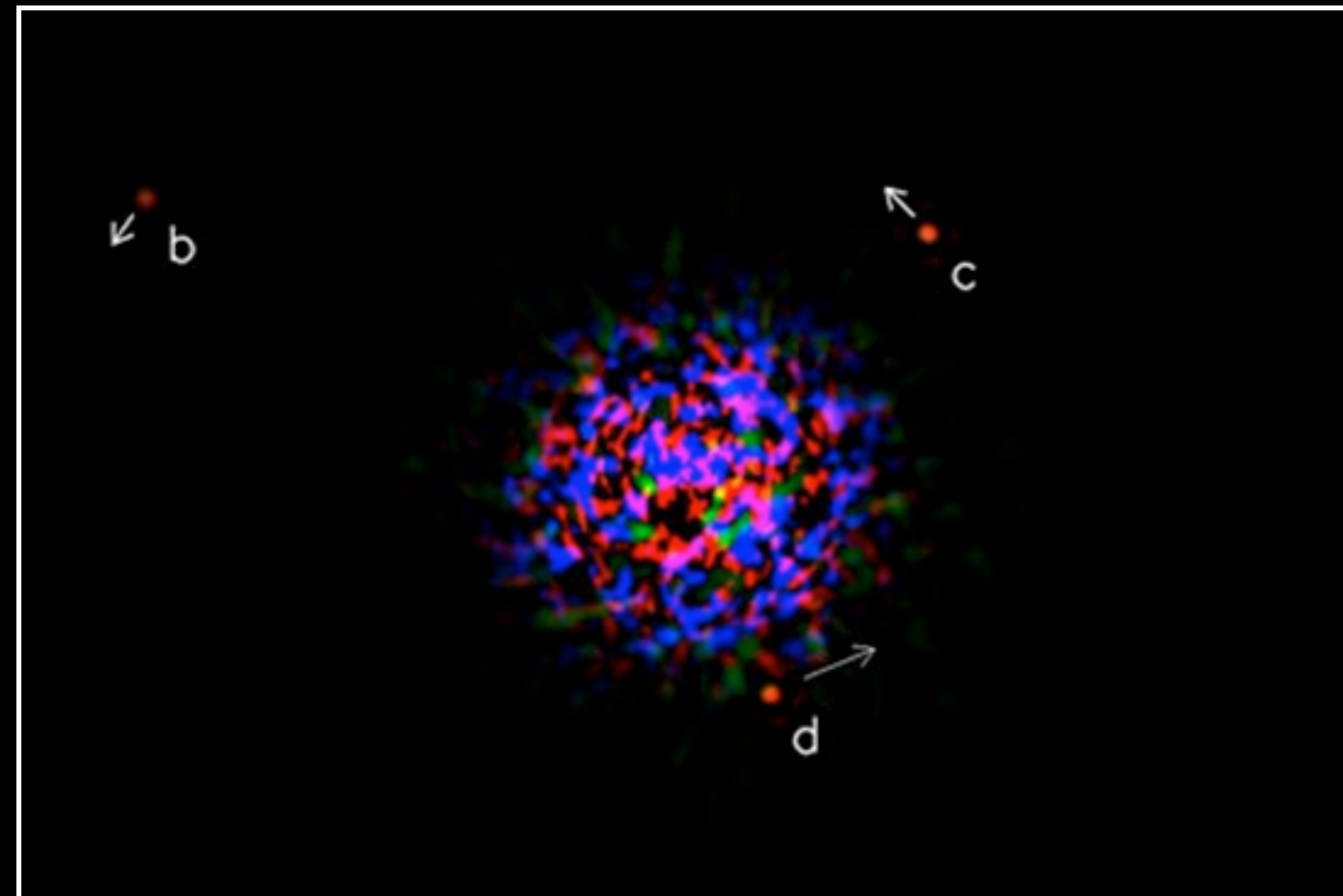
Lafreniere et al, 2007, ApJ, 660, 770

example of LOCI observations



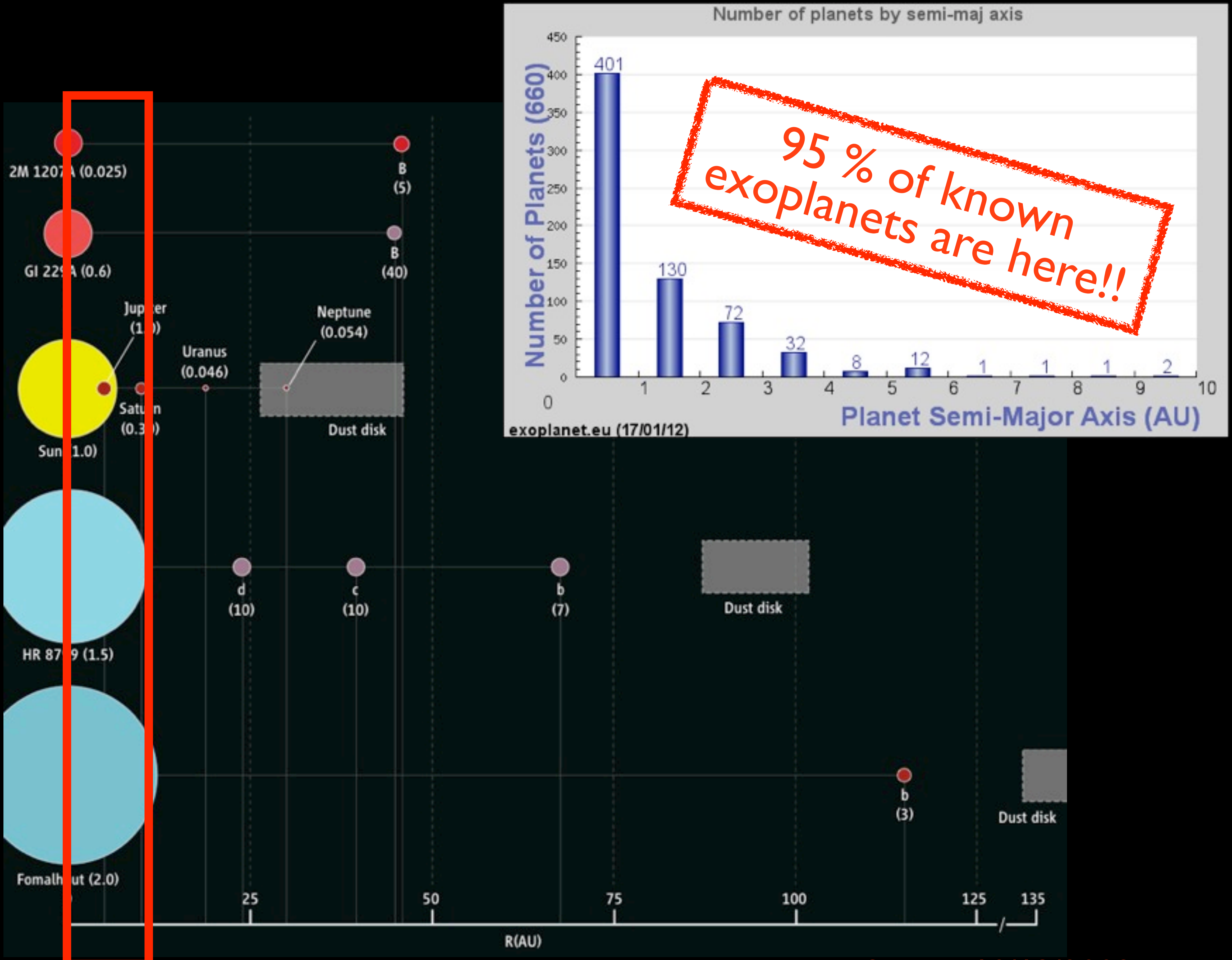
“conservative” LOCI image of LkCa 15 by HiCIAO

Thalman et al, 2010, ApJL, 718, 87

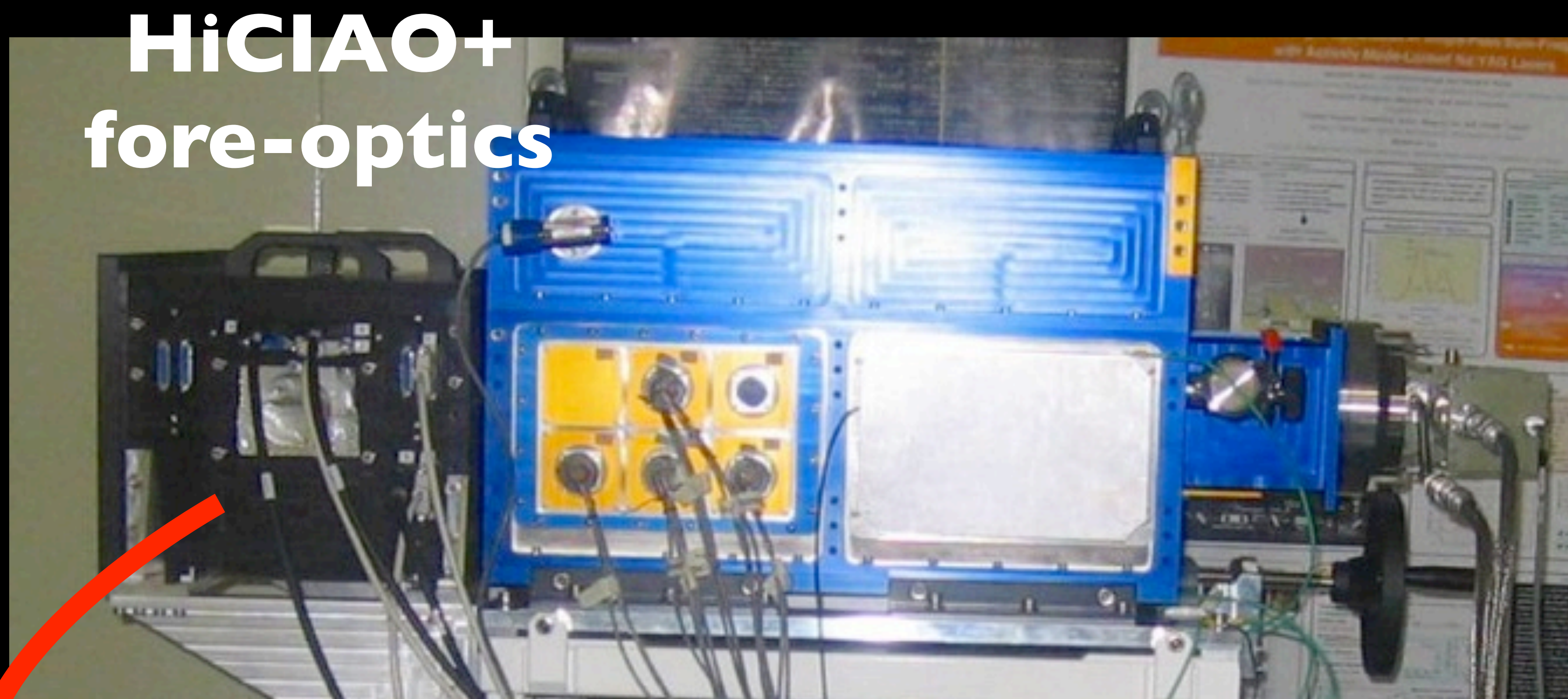


“iconic” LOCI image of the planetary system orbiting HR 8799

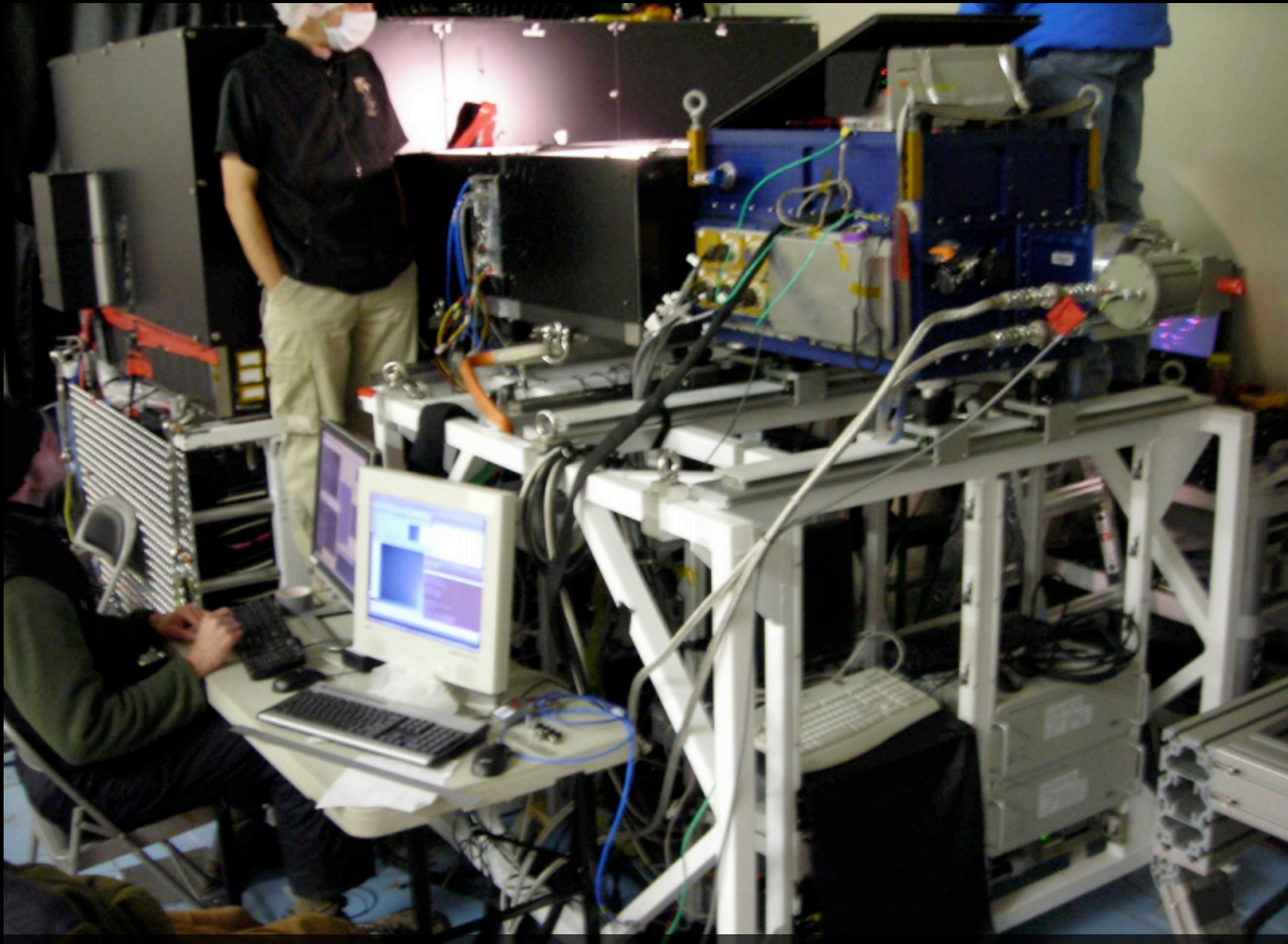
Marois et al, 2008, Science, 322, 1348



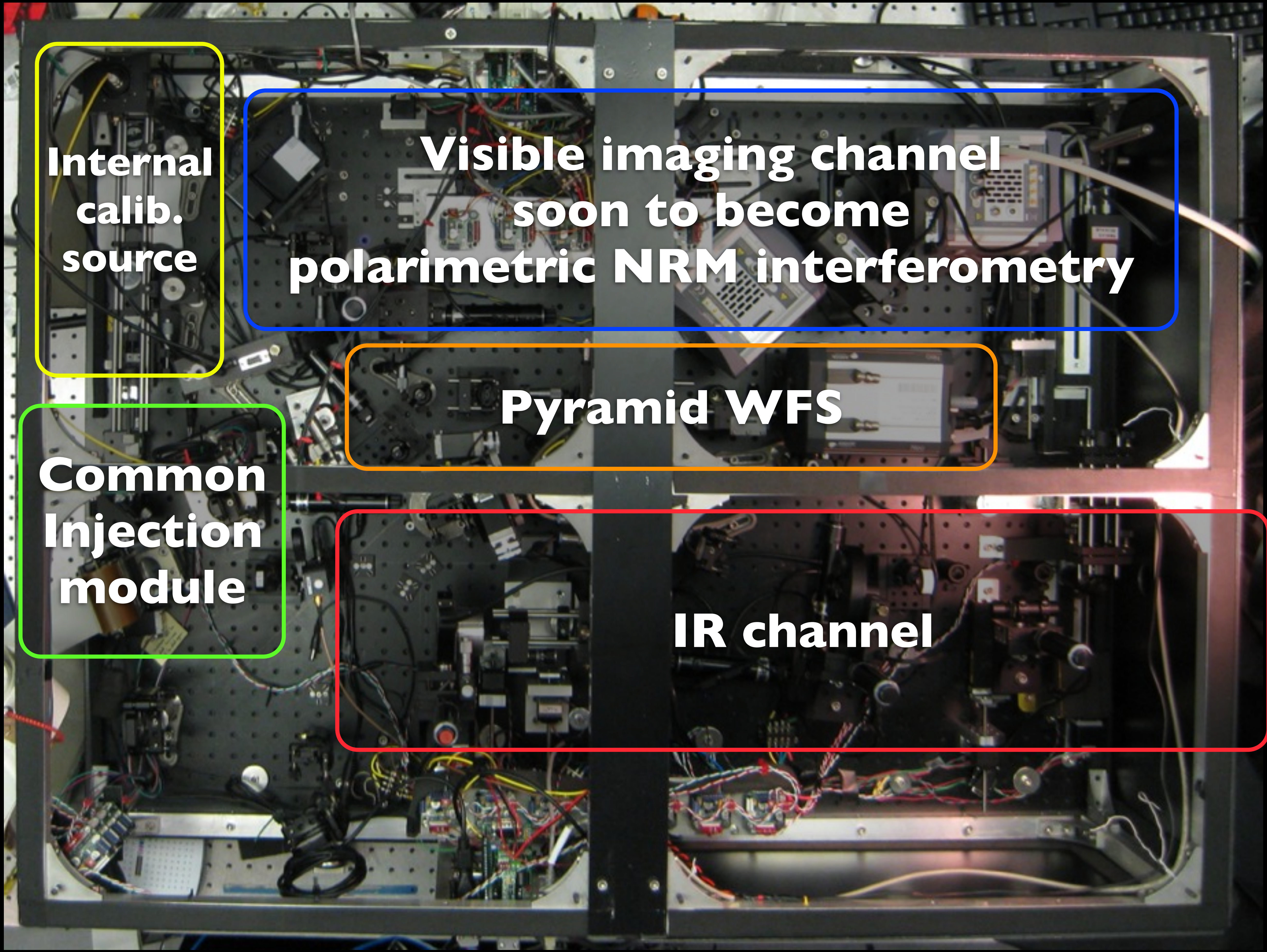
Marley, Sci. Exp, 10/13/2008


HiCIAO+
fore-optics


HiCIAO+
SCExAO



SCExAO engineering run September 2011

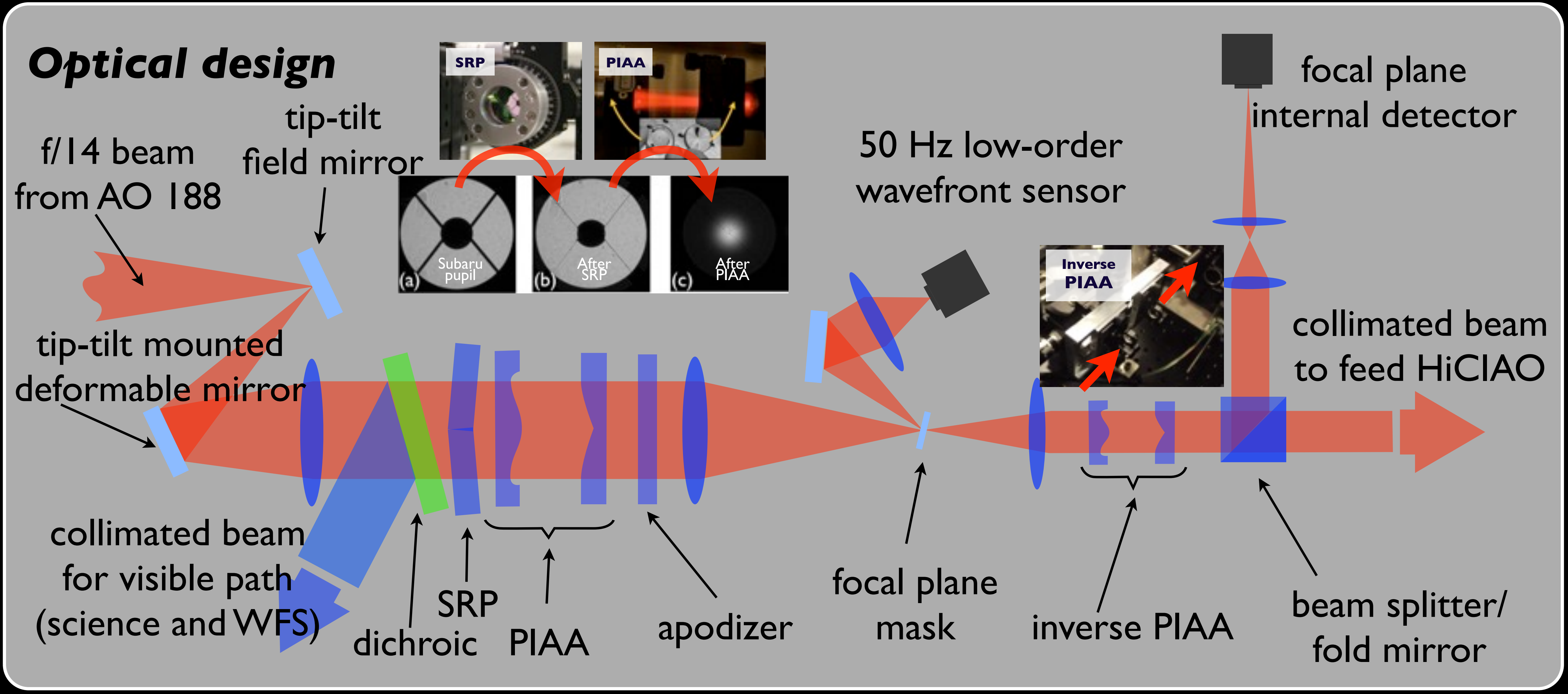

Internal calib. source
Visible imaging channel soon to become polarimetric NRM interferometry
Pyramid WFS
Common Injection module
IR channel

The SCExAO project

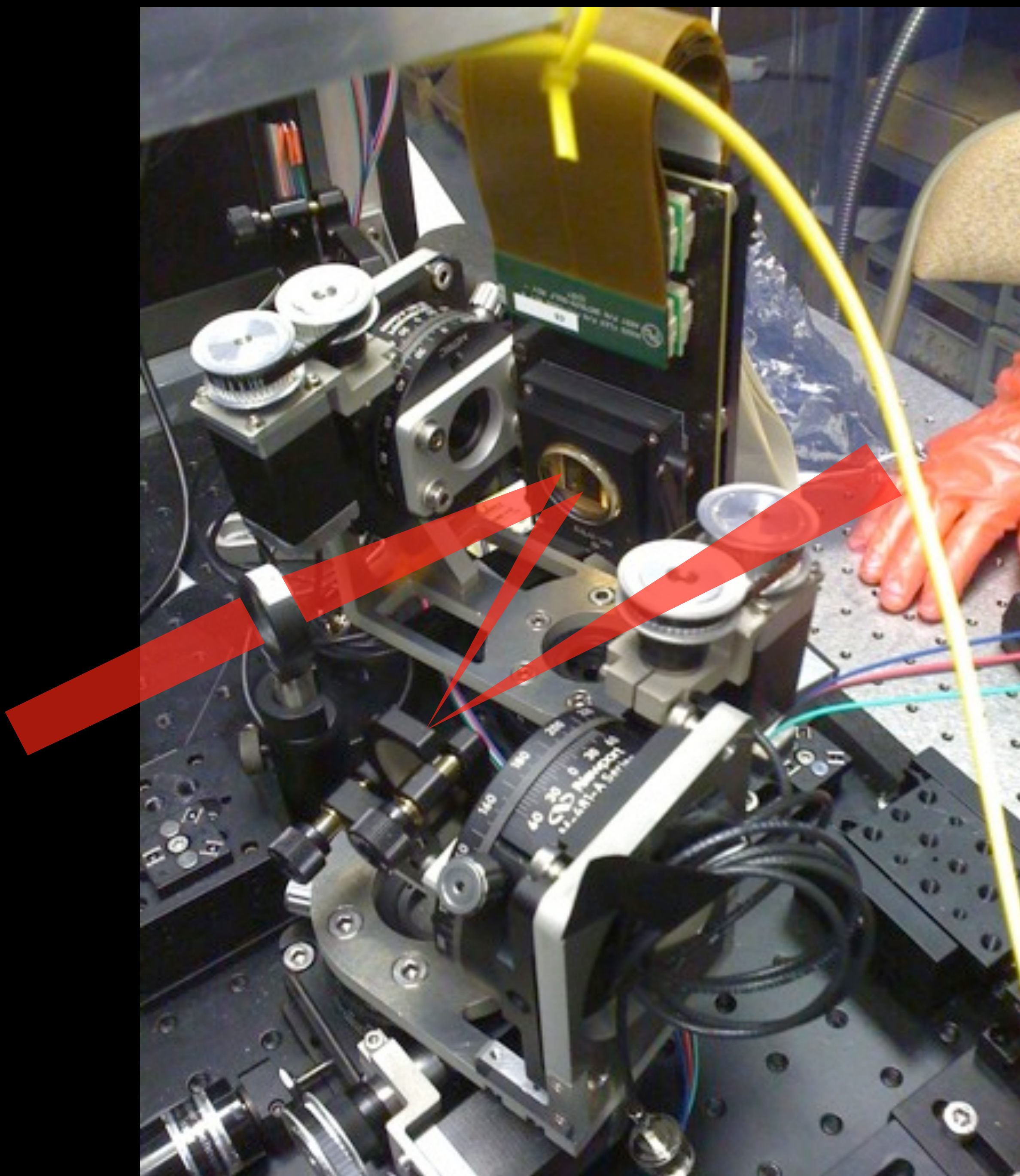
Taking advantage of a series of in house developments (PIAA, CLOWFS) and the existing infrastructure (AO188 + HiCIAO) to put in the same box:

- a high-efficiency, high-performance PIAA-based coronagraph
- all the calibration tools we can think of now (wavefront sensors, active control of the focal plane image with a DM, post processing techniques, optional NRM)
- simultaneous diffraction limited visible imager

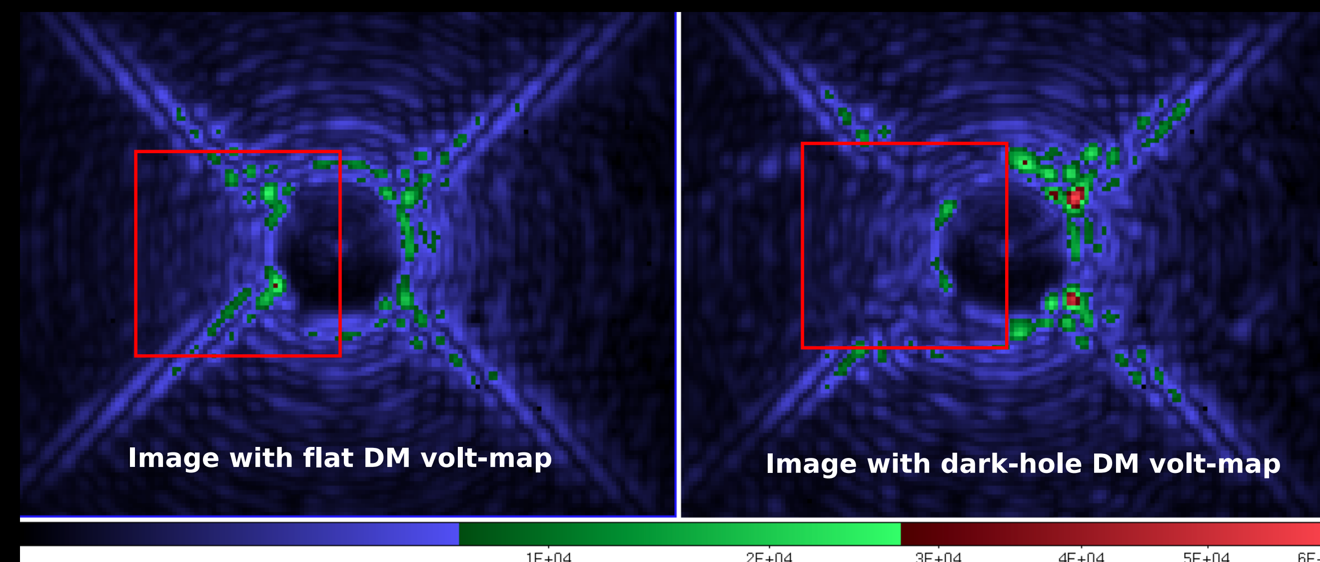
While keeping the design flexible for future improvements.



Active speckle control



Instead of using a passive approach, and wait for the sky rotation like in ADI, use a DM with many actuators (~1000) gives active control of the speckles

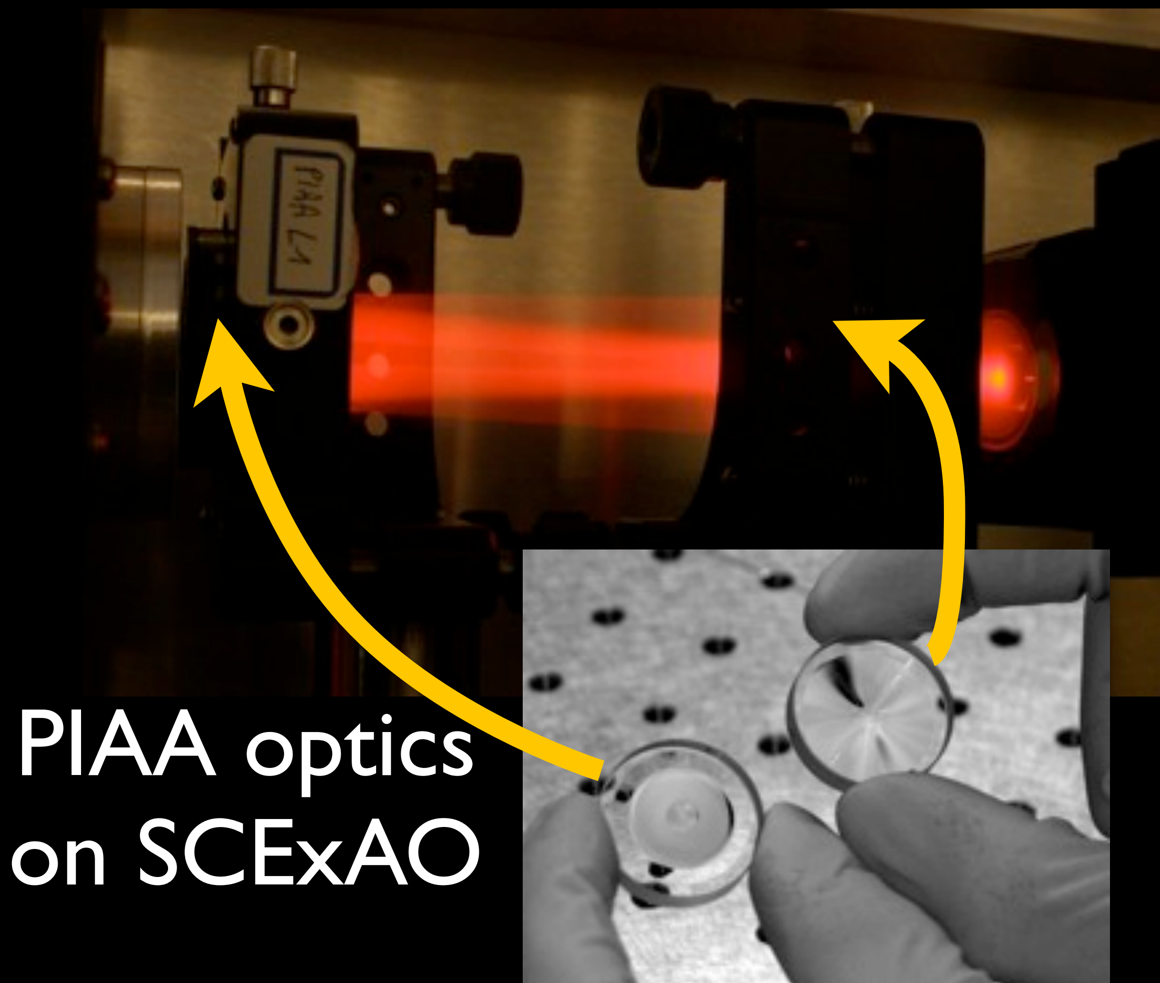


Strategy shared with comparable projects (GPI, SPHERE).

The true advantage of SCExAO is its **small IWA**

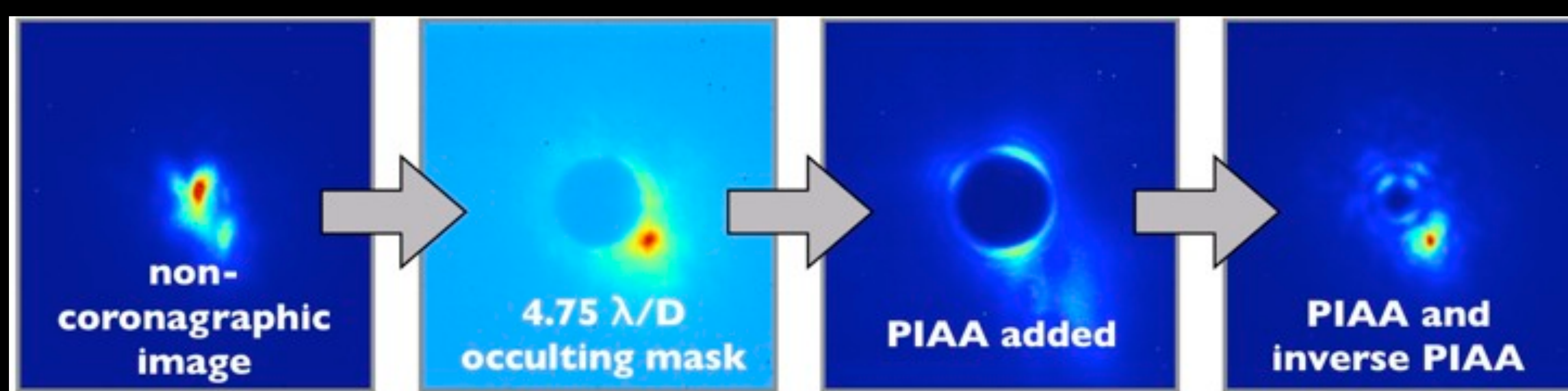
Martinache & Guyon, 2011, AO4ELT
On sky results soon!

High contrast @ 1 lambda with PIAA



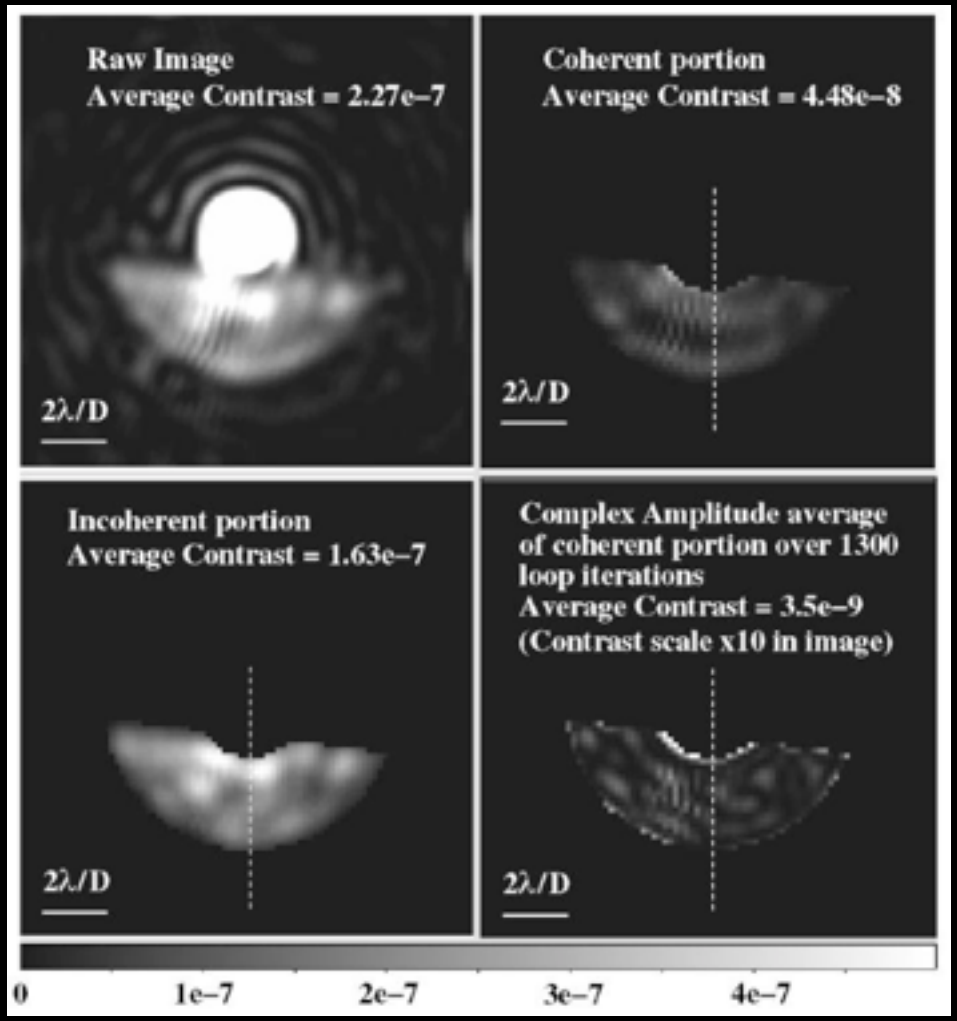
Martinache & Guyon, 2011, AO4ELT

First on sky demonstration (Sept. 2011)



Images by HiCIAO

Active speckle control



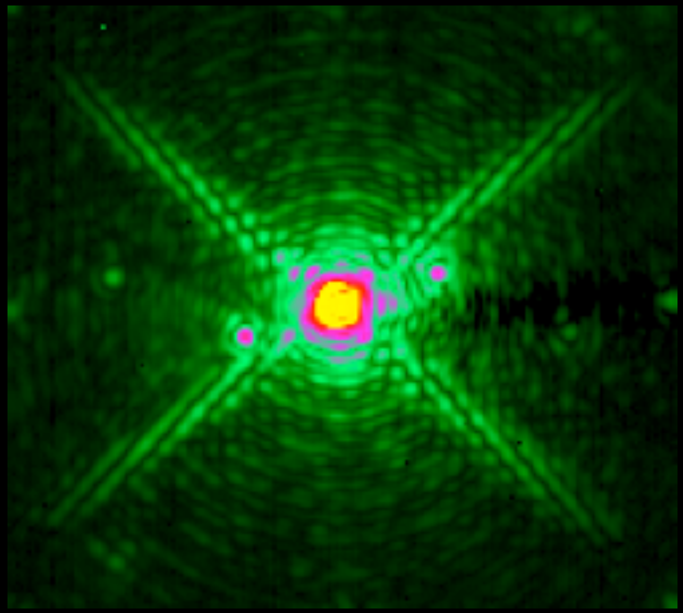
Example of PIAA-based coronagraph high contrast results (laboratory):

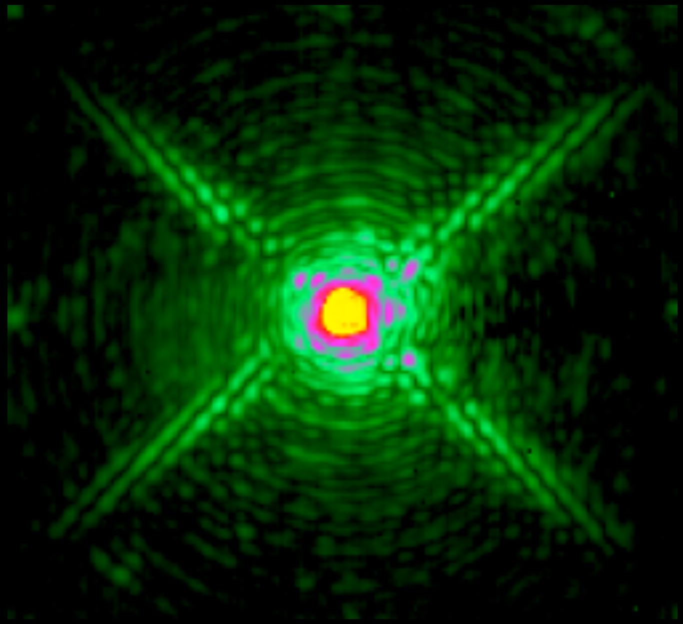
DM diversity identifies "coherent" fraction of the light in control FOV. Gains two orders of magnitude over raw contrast

Guyon et al, 2010, PASP, 122, 71

DM wavefront diversity in the presence of turbulence with SCExAO

Martinache et al, 2012, in prep





SCExAO plans

Phase 1:

1. High efficiency PIAA-based coronagraph
2. Active speckle probing with DM to measure the coherence of the field

Full phase 1 demonstration, summer 2012

Planned and ongoing upgrades:

1. Fast wavefront sensor for true extreme-AO
2. Visible polarimetric NRM-interferometry
3. J,H,K-band IFS (CHARIS) by Princeton University

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