Resolving Disk Structure with Adaptive Secondary AO

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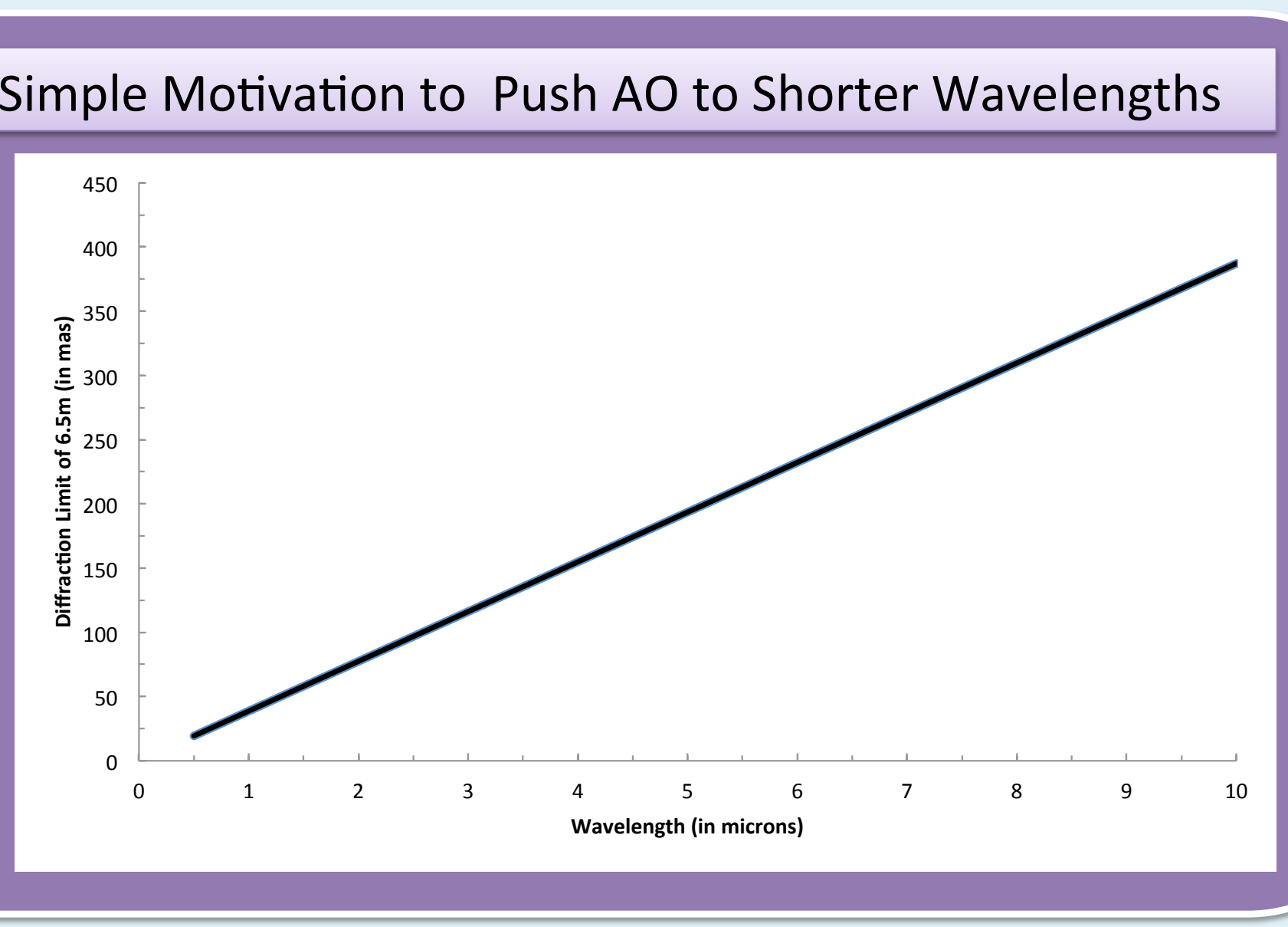
Motivation

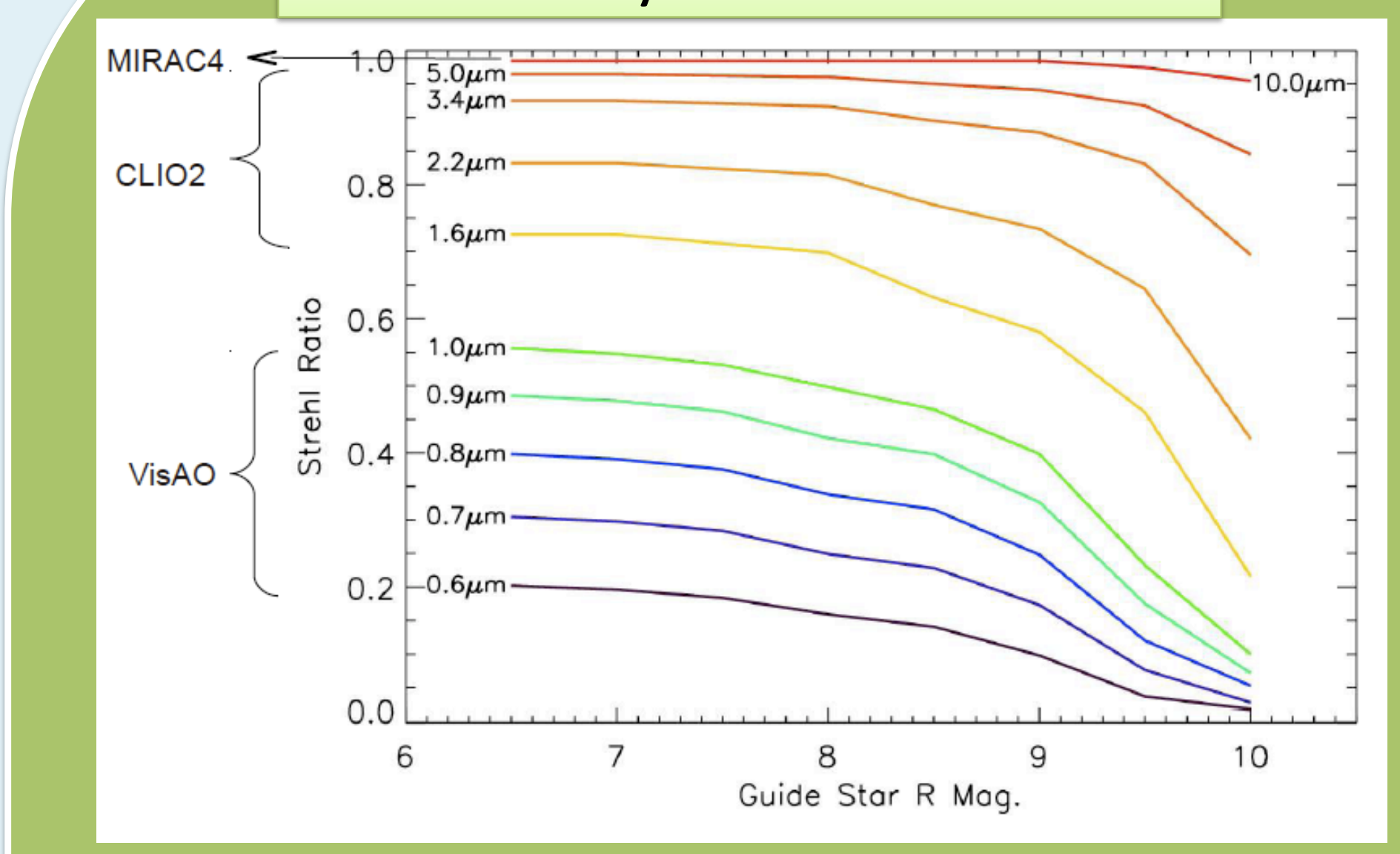
A great deal of information about the process of grain growth and planet formation can be revealed by the study of circumstellar disks in the near IR with high spatial resolution adaptive optics techniques using adaptive secondary mirrors (ASMs). With current ASM technology on the MMT, we are able to probe the existence of water ice (likely a key component of planet formation) and average grain properties of circumstellar disks. This method, pioneered by Honda et al. (2009), takes advantage of the high albedo of icy circumstellar disks at the 3.09micron ice feature relative to the nearby continuum to constrain the water ice abundance and average grain properties of the disk. We will present the results of our pilot study on GM Aur. With the success of the LBT ASM (Esposito et al. 2010), the future of disk imaging at the high spatial resolutions achievable by well-sampled (d~21cm), high actuator count adaptive secondary mirrors appears bright. In fact, the simulated performance of the soon-to-be-integrated Magellan ASM reveals that the system is likely to achieve moderate Strehls and high spatial resolutions (~20mas) into the visible wavelength regime. This gives the system the potential to reveal disk morphology on scales as small as 2-3AU, allowing an exciting potential to resolve heretofore unresolved disk features such as disk gaps where planets may be forming.

Simple Motivation to Push AO to Shorter Wavelengths

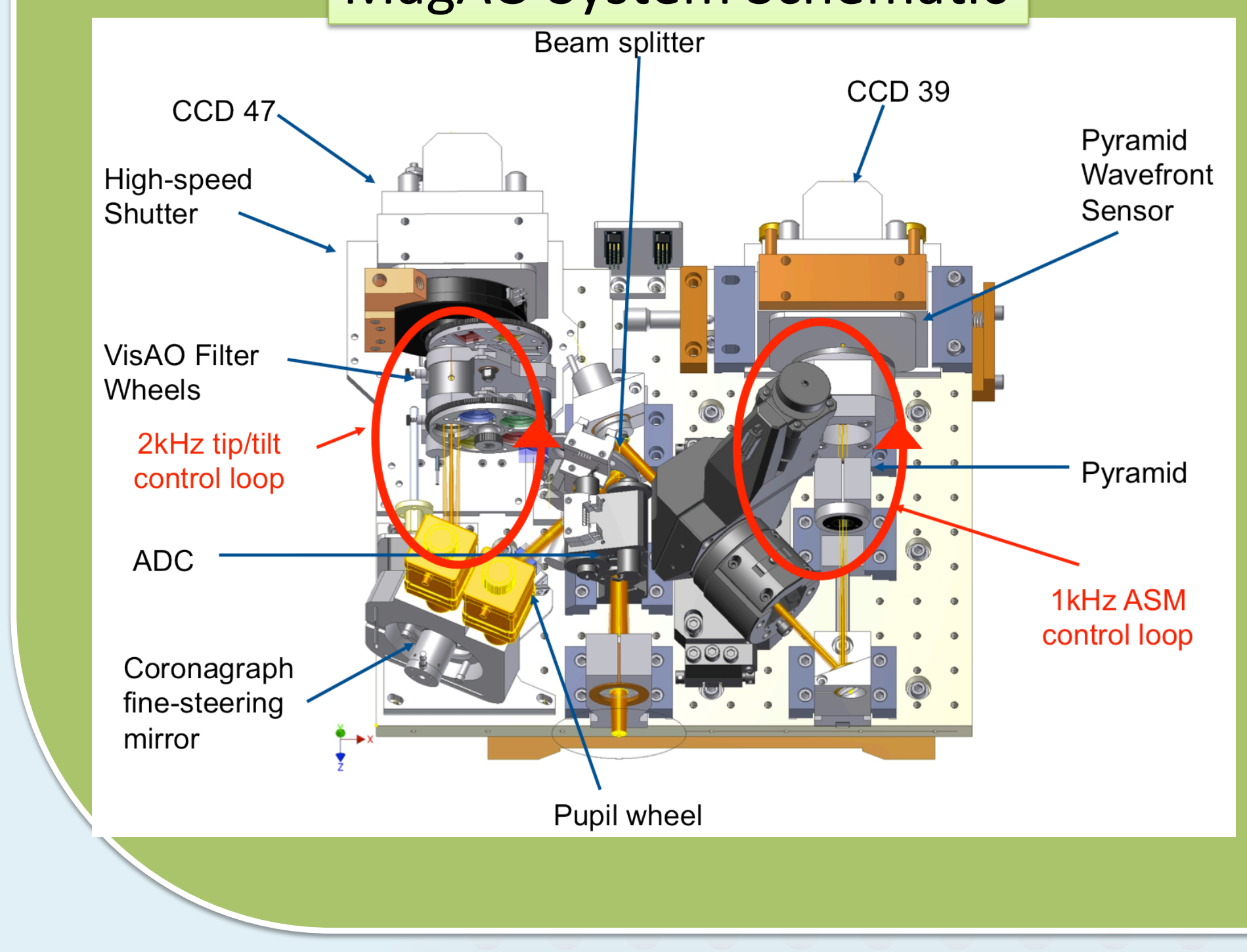


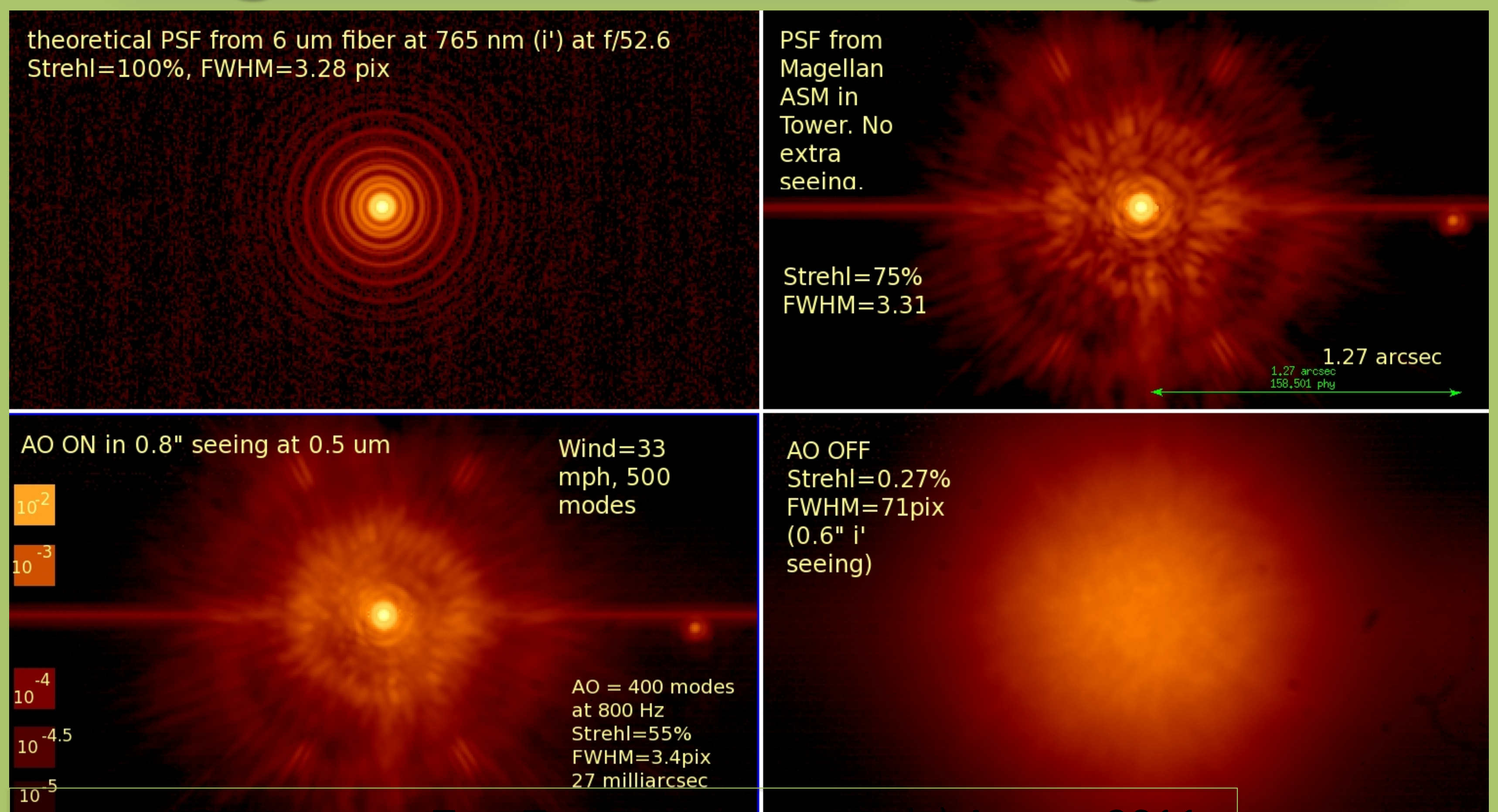
Magellan and Visible Light AO

Simulated System Performance



MagAO System Schematic

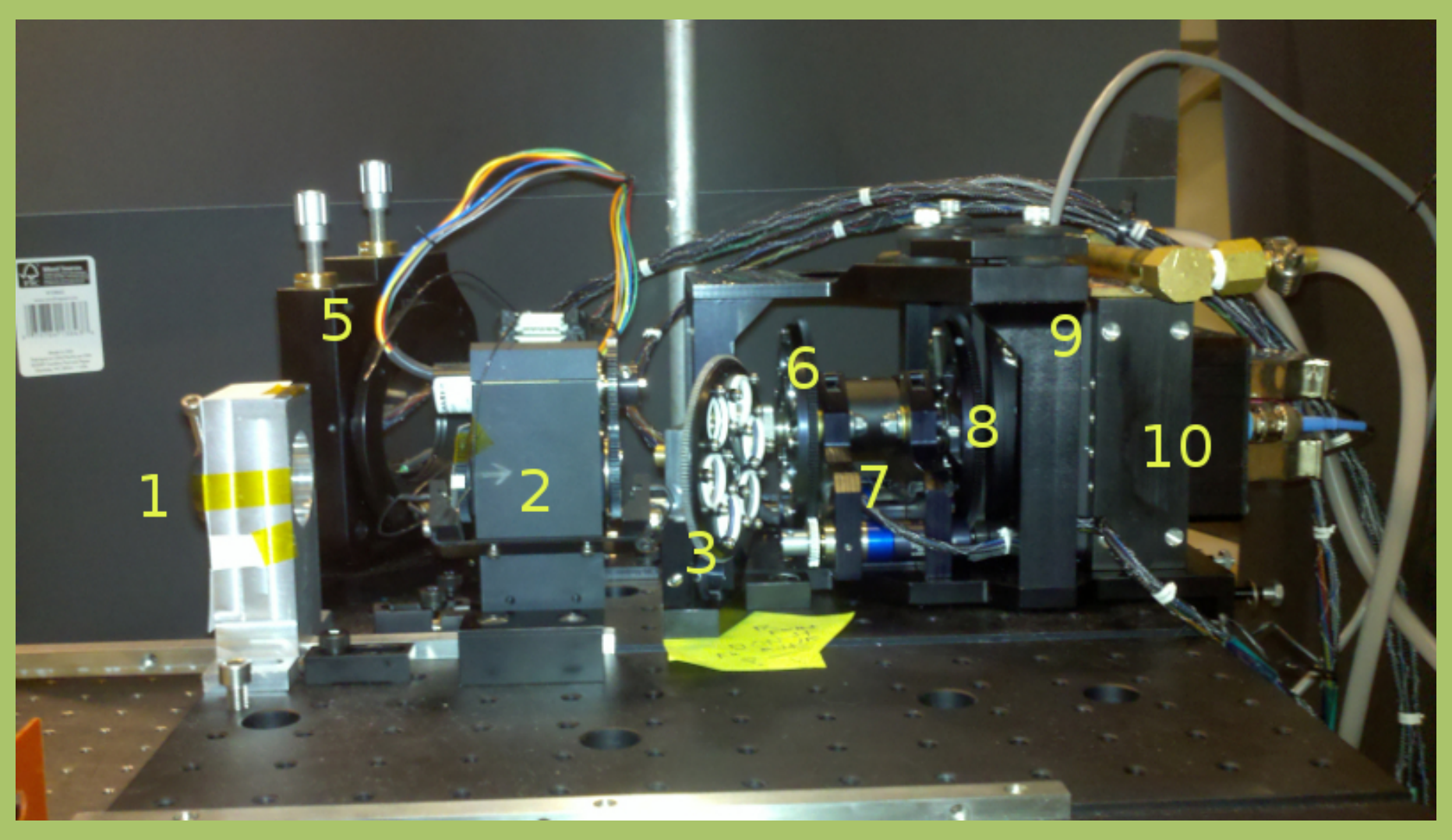




Arcetri Observatory Test Tower (Florence, Italy) August 2011

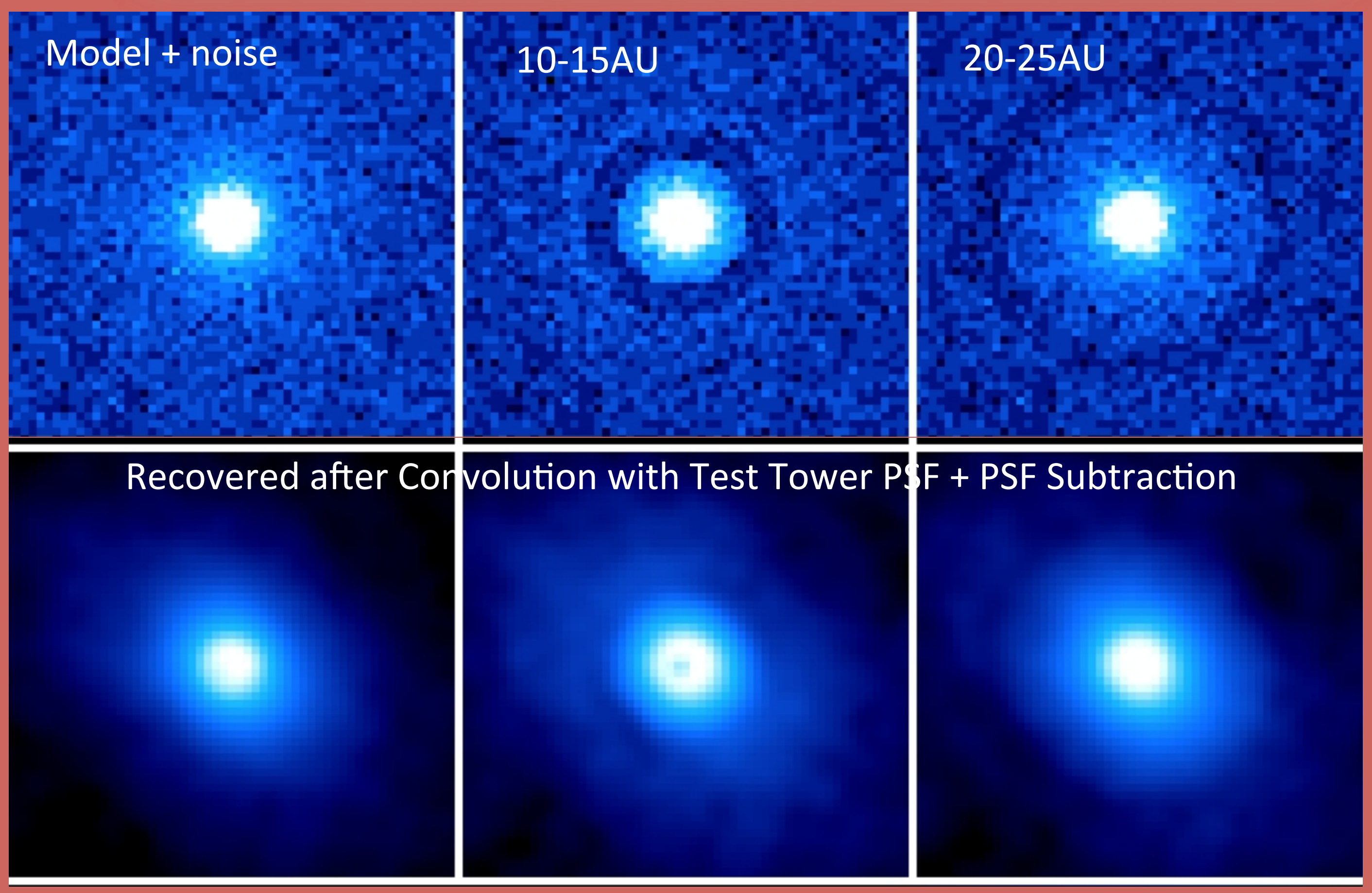
System Parameters
6.5m Primary
85.1cm Adaptive Secondary
585 actuators
23cm pitch

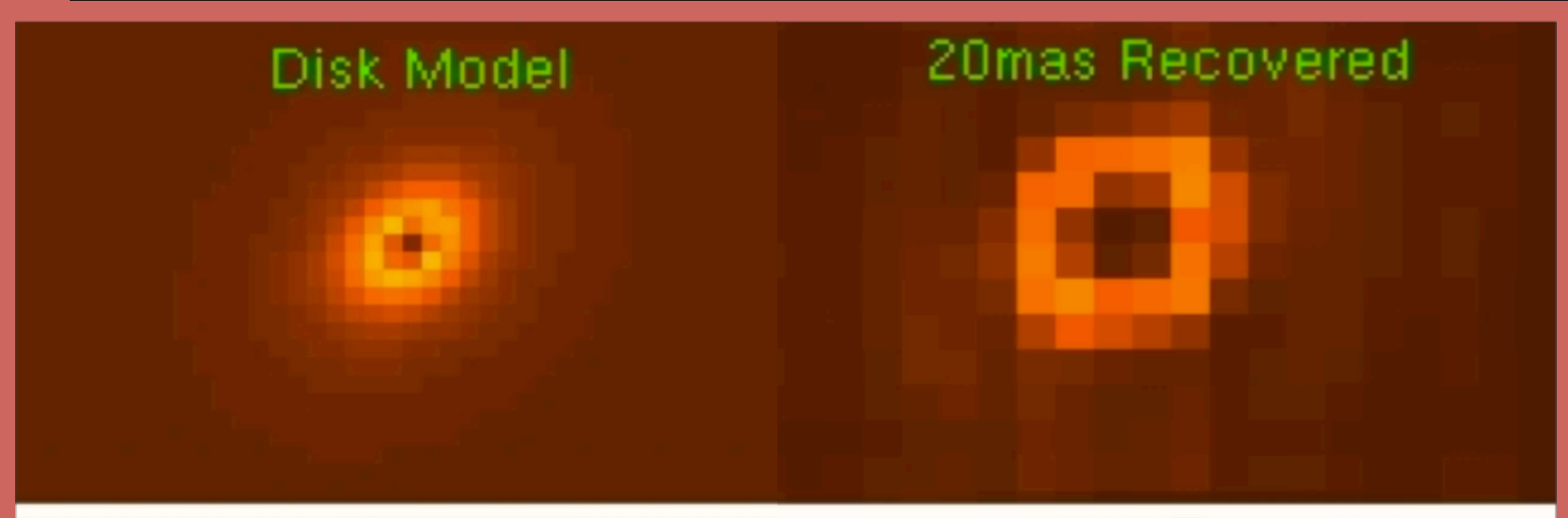
Cameras
Mirac4 10µm (50-100mas/pix)
Clio2 3-5µm (18 or 30mas/pix)
VisAO 0.5-1µm (8.5mas/pix)



The numbers label specific components:
1: The input lens
2: The ADC mount, containing an early prototype of the custom 2-triplet ADC designed by Derek Kopon.
3: The beamsplitter wheel, a.k.a. filter wheel 1. This allows us to select how much and what wavelength of light is sent to the WFS and to our science camera. Options range from 10-90%.
4: The Wollaston prism on its lift. This splits the beam in 2 to enable our simultaneous differential imaging (SDI) mode.
5: Our tip-tilt gimbal mirror. This is a temporary solution, which we hope to replace with a high speed tip-tilt mirror.
6: Filter wheel 2. This wheel contains our main photometric filters, currently: SDSS r', i', z', and a filter which passes wavelengths longer than 950nm.
7: Baffle tube. We plan to add a pickoff occulting spot here, to feed a tip-tilt and Strehl sensing camera which will mount on the platform over the tube. These are planned future improvements.
8: Filter wheel 3: This wheel will contain our SDI filters (2 filters in one cell at H-alpha, [OI] 6300A and [SII) 6700A) and in the future our occulting spots (to block the bright central star light).
9: The shutter. You can see our vibration isolation system (the rubber grommets). These are the only place that the shutter mount contacts the rest of the camera.
10: The CCD47. The liquid cooling attachment, another temporary device, keeps our dark current low.

Optical Disk Simulations

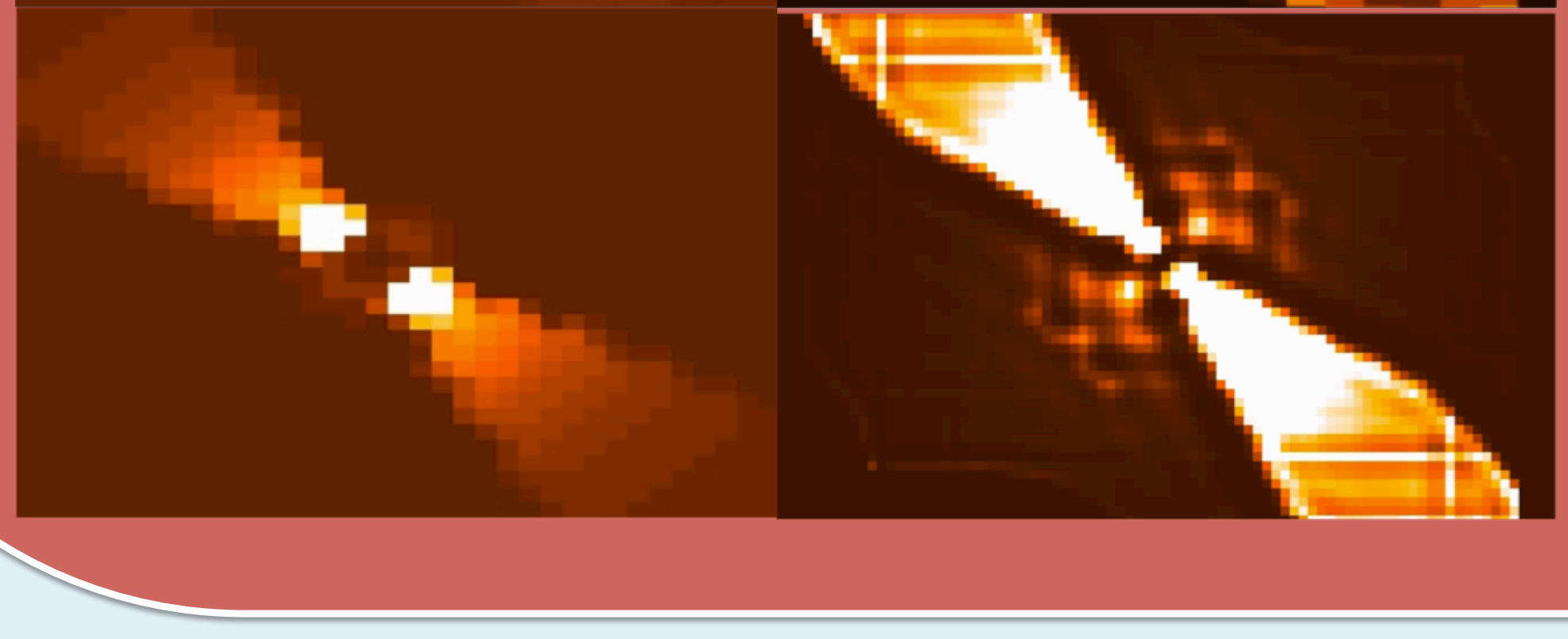




Case 1
R^{-2} disk
At 140pc

Case 2
R^{-2} disk
5-10AU gap

Case 3
Jet
Total Flux=Case 1-2

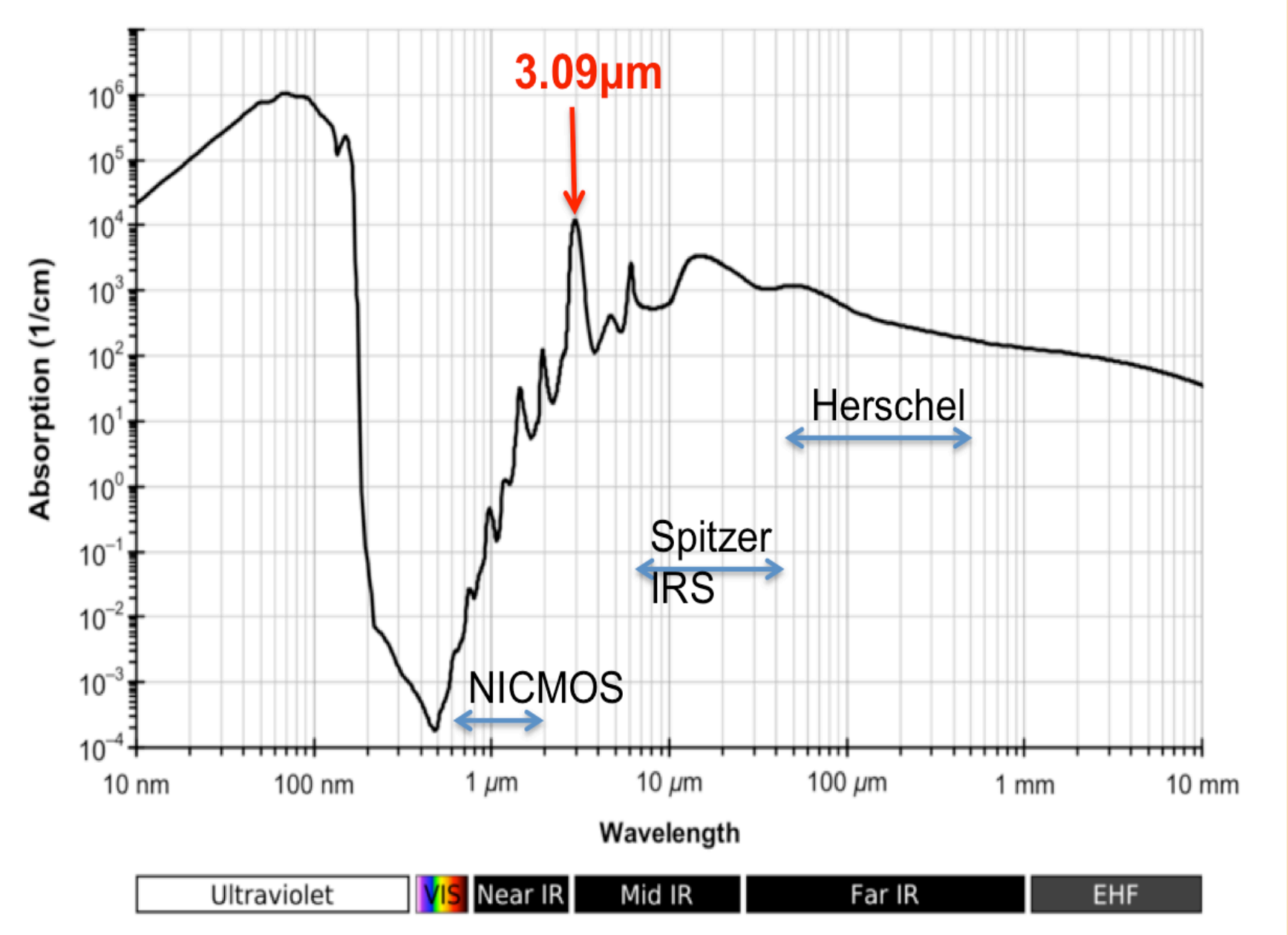


Case 4
Jet + Disk
10:1 Flux Scaling

NIR Ice Mapping

FOV	512 x 1024 15” x 30”
Wavelength Range	1-5.3µm
Read Noise	93 e-
Pixel Scale	30 mas

- ❖ 3.09µm ice feature is only accessible from the ground
- ❖ Deficit in scattered light indicates presence of water ice grains in disk
- ❖ Honda (2009) demonstrated feasibility in scattered light Herbig Ae disk



Our Attempt at the MMT 12/09
~15-25% Strehls (typically 80%)
2010 Clio2 Upgrade

Clio2 with MMT-AO
5σ AO Surface Brightness Limits
In Vega mags per sq. arcsec

Filter	5 min*	60 min
Ks	13.0	14.3
L’	11.5	12.9
M	9.7	11.0