The CHARA Array
Adaptive Optics Program

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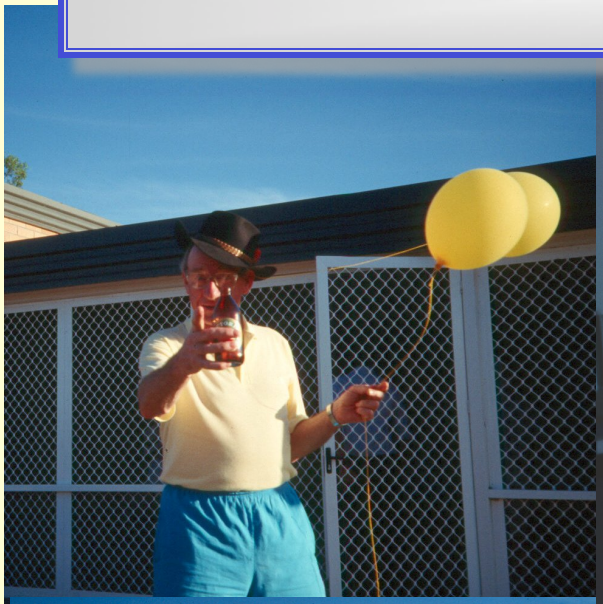
Georgia State University

“Back in the day” (1991?)



CHARA/GSU Participants & Funding

Principal Technical Staff:

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Laszlo Sturmann*
Judit Sturmann*
Nils Turner*

Affiliated GSU Faculty:

Douglas Gies
Todd Henry
Russel White

****Mt. Wilson-based***

Support Staff:

Larry Webster, Site Manager*
Chris Farrington, Operator*
Steve Golden, Asst. Site Manager*
Norm Vargas, Operator*
Nic Scott, Operator/Grad-Student*
Brenda Stith, Business Manager
Dwayne Torres, Machinist

Construction Funding (~$20 M):

National Science Foundation
Georgia State University
W. M. Keck Foundation
David & Lucile Packard Foundation

Current Science Funding (~$1.5 M yr^{-1}):

National Science Foundation
Georgia State University
College of Arts & Sciences
Vice President for Research

The CHARA Collaboration

First science publication..... 5 years later!

FIRST RESULTS FROM THE CHARA ARRAY. I. AN INTERFEROMETRIC AND SPECTROSCOPIC STUDY OF THE FAST ROTATOR α LEONIS (REGULUS)

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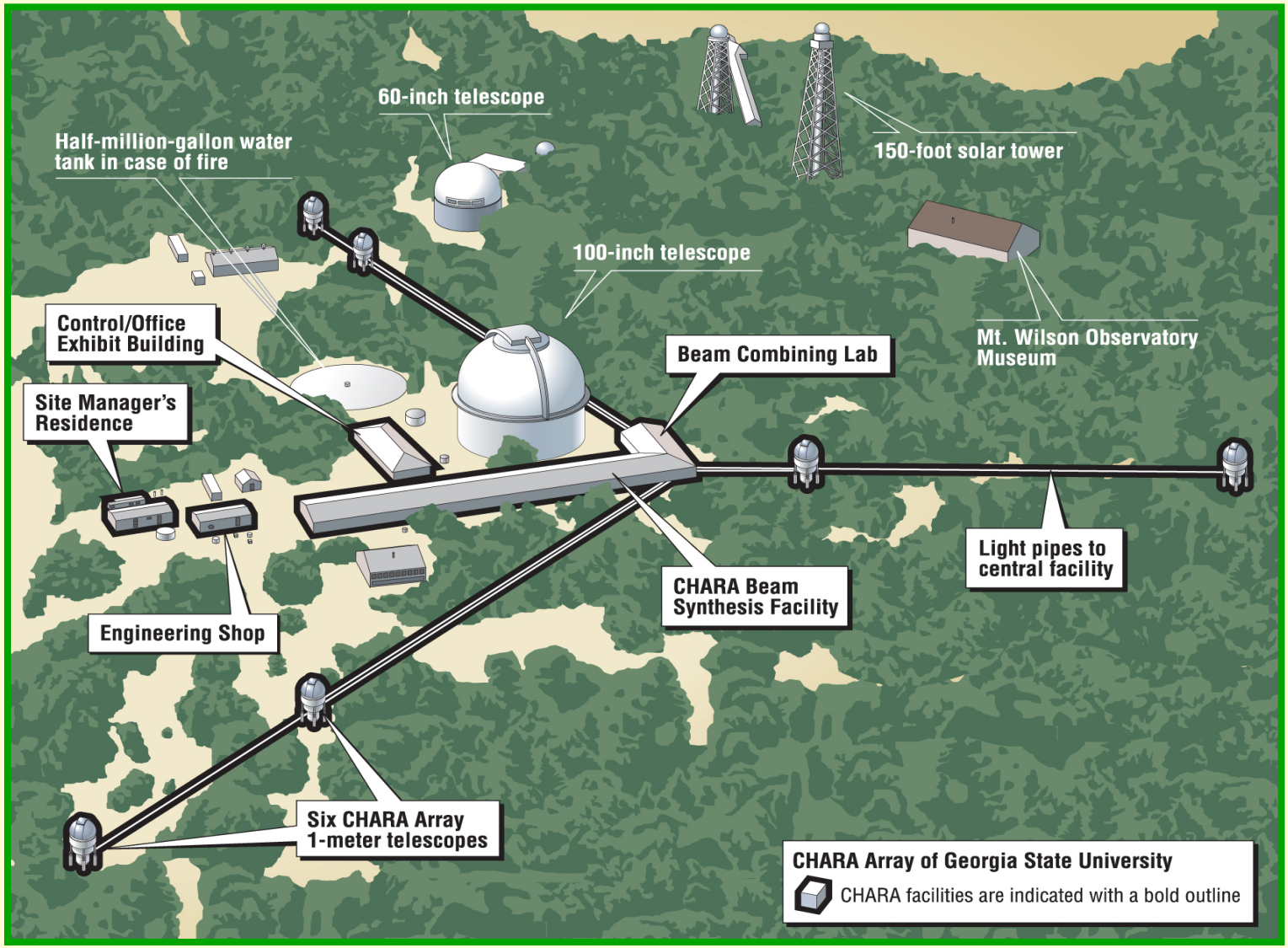
ABSTRACT

We report on *K*-band interferometric observations of the bright, rapidly rotating star Regulus (type B7 V) made with the CHARA Array on Mount Wilson, California. Through a combination of interferometric and spectroscopic measurements, we have determined for Regulus the equatorial and polar diameters and temperatures, the rotational velocity and period, the inclination and position angle of the spin axis, and the gravity darkening coefficient. These first results from the CHARA Array provide the first interferometric measurement of gravity darkening in a rapidly rotating star and represent the first detection of gravity darkening in a star that is not a member of an eclipsing binary system.

Subject headings: infrared: stars — stars: fundamental parameters — stars: individual (α Leonis, Regulus) — stars: rotation — techniques: interferometric

Layout of the CHARA Array

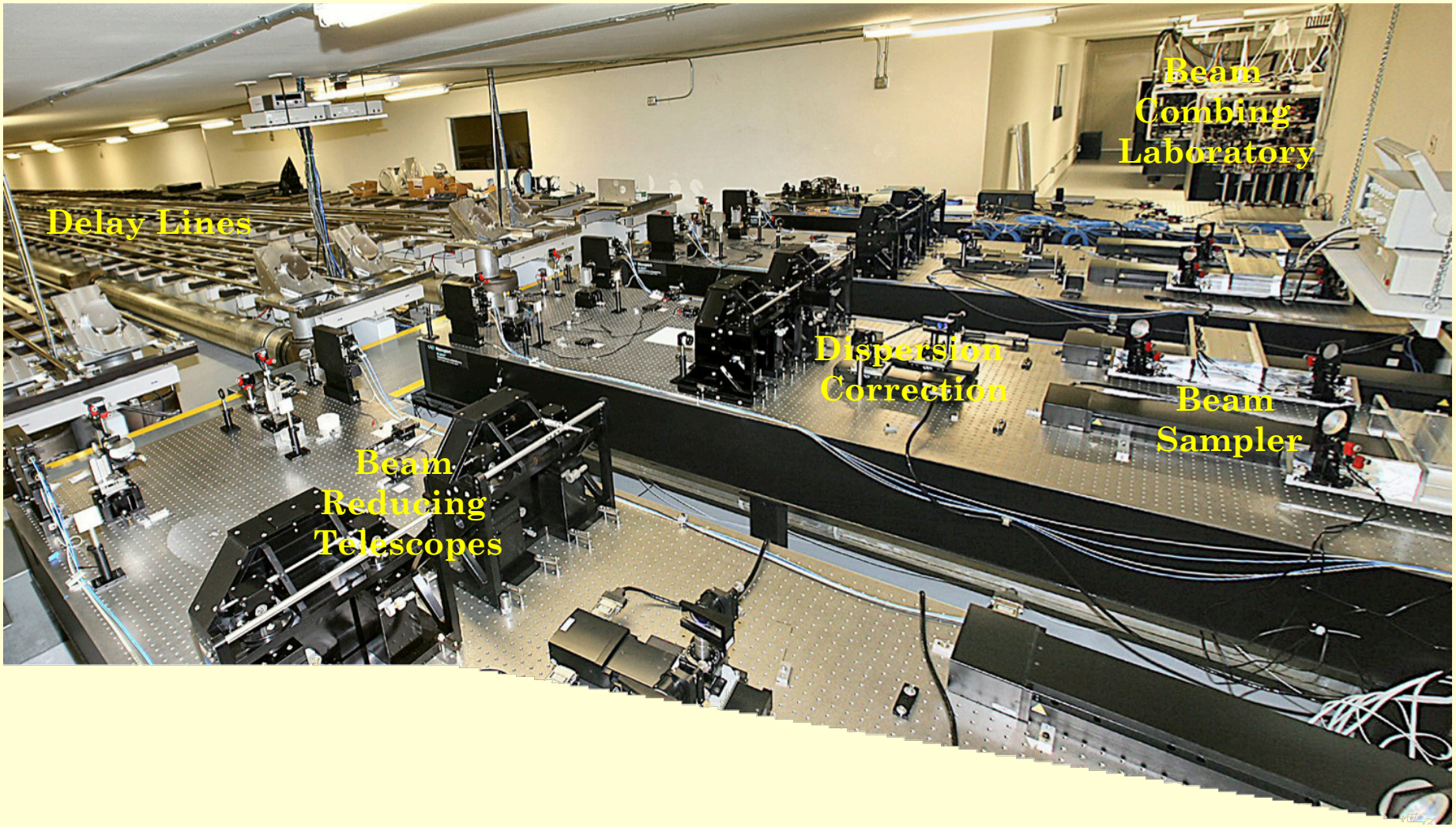


Telescopes

CAD by Laszlo Sturmann

Photo by Steve Golden

Optics Laboratory

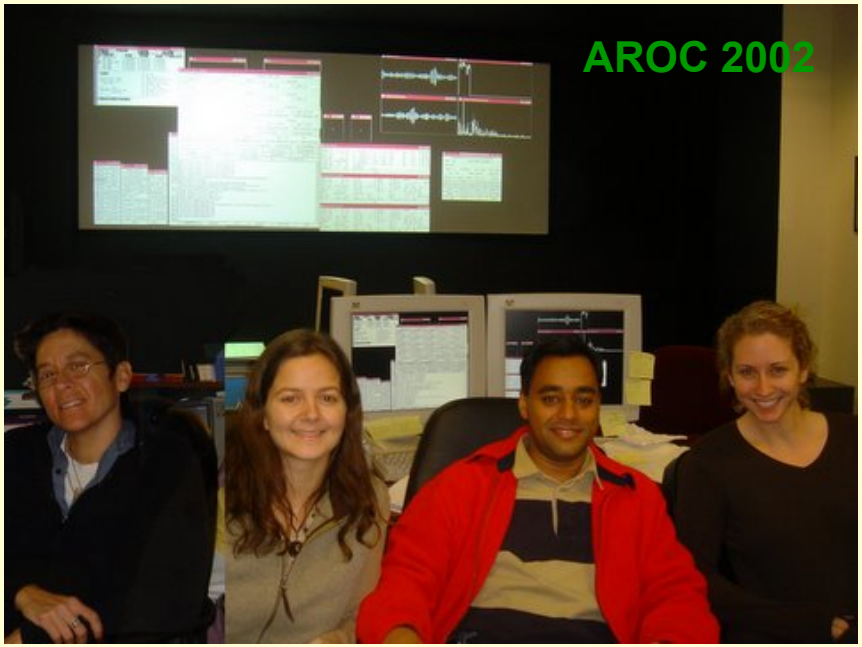


The 30 second CHARA tour.

“Beam Combiners are us”

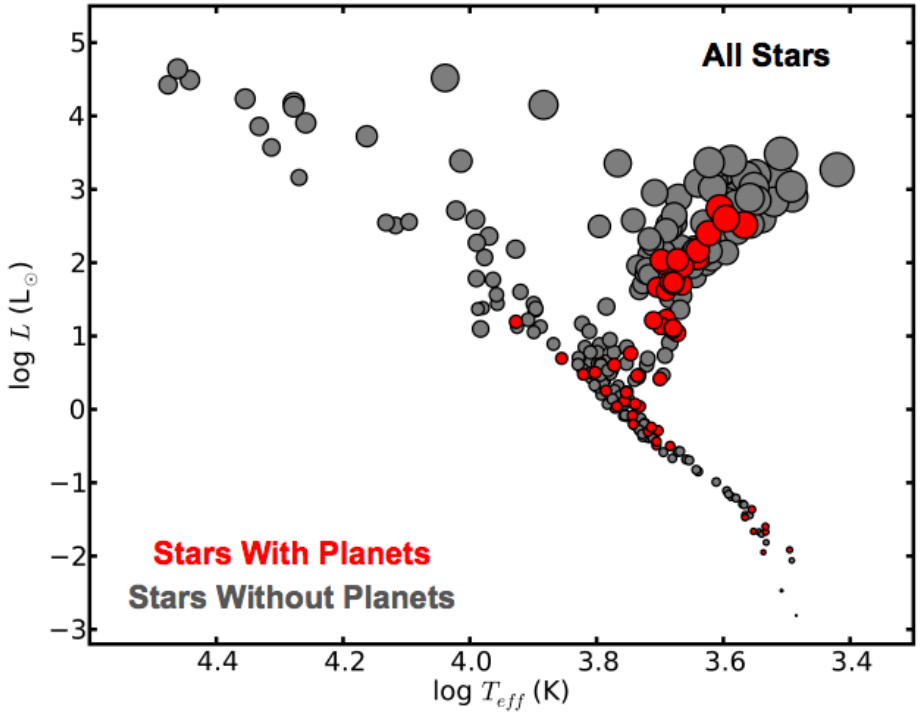
- CHARA CLASSIC – 2 way open air J, H & K
- CHARA CLIMB – 2x3 way open air J, H & K
- FLUOR – 2 way fiber based K band
- MIRC – 6 way fiber based imager J, H & K
- VEGA – 4 way open air V,R,I R=30000
- PAVO – 3 way aperture plane V,R,I
- CHAMP – 6 beam fringe tracker J, H & K
- More to come… (MYSTIC, FRIEND….)

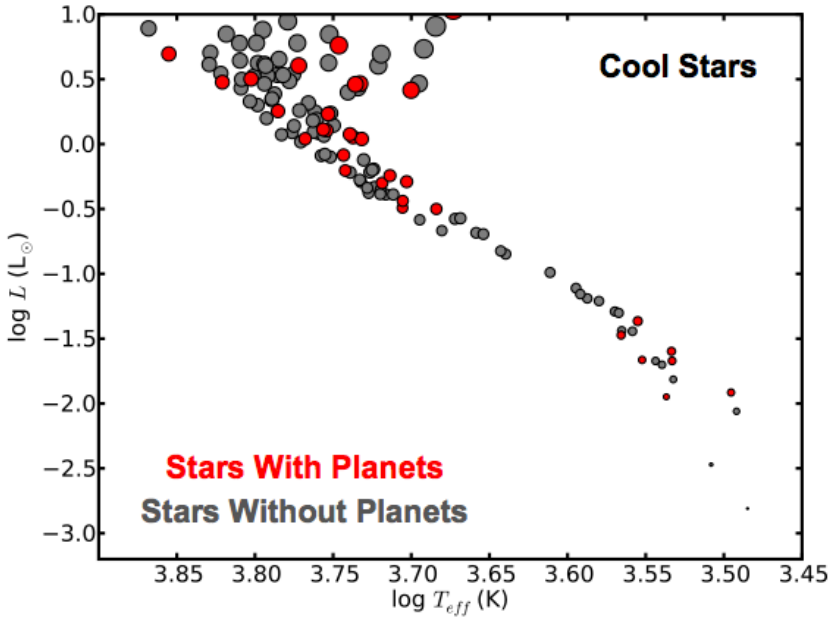
ROCMI 2006



An Interferometric HR Diagram

Compliments of Tabetha Boyajian and Kaspar von Braun



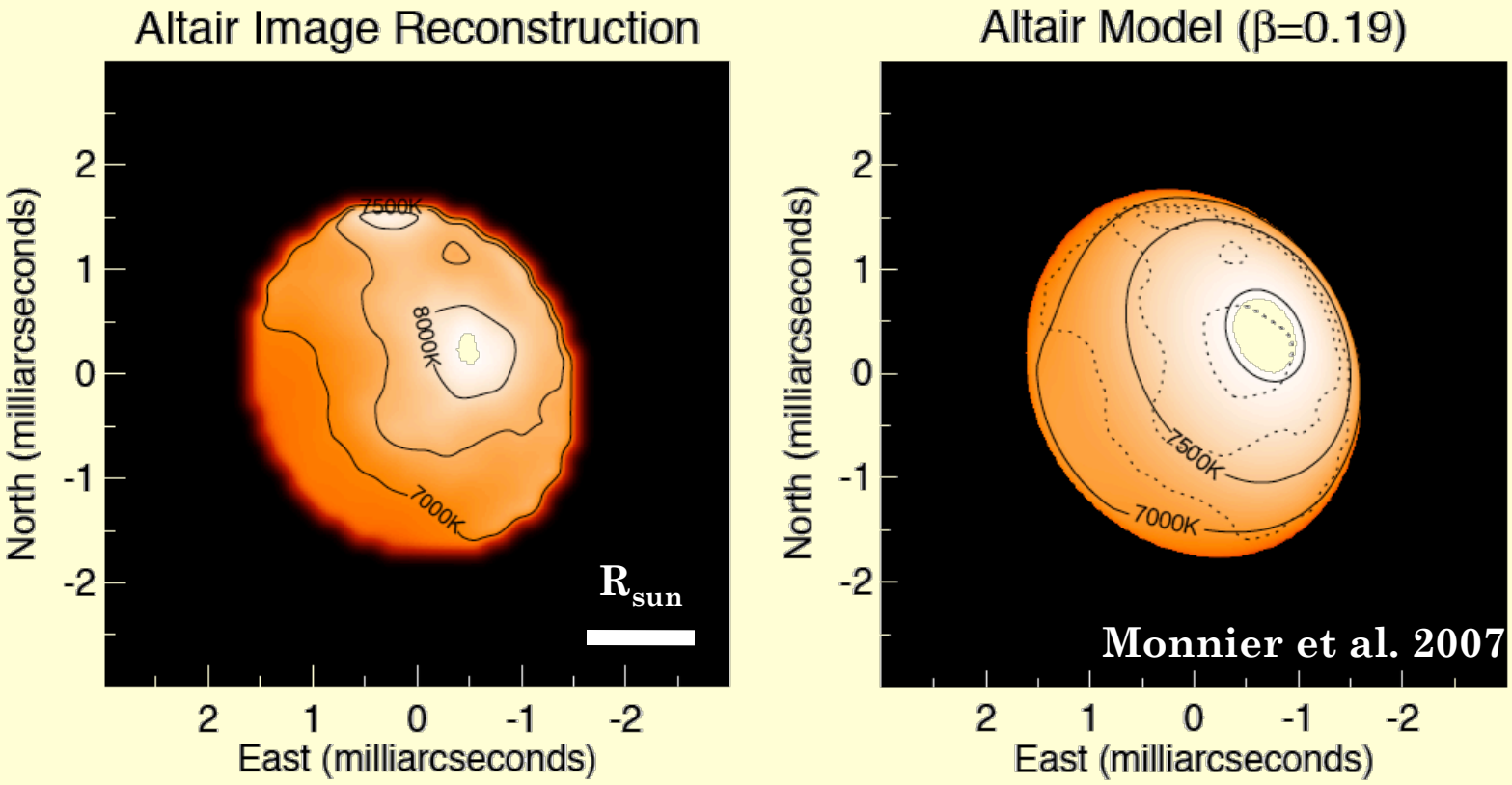


Log T_{eff} (K)

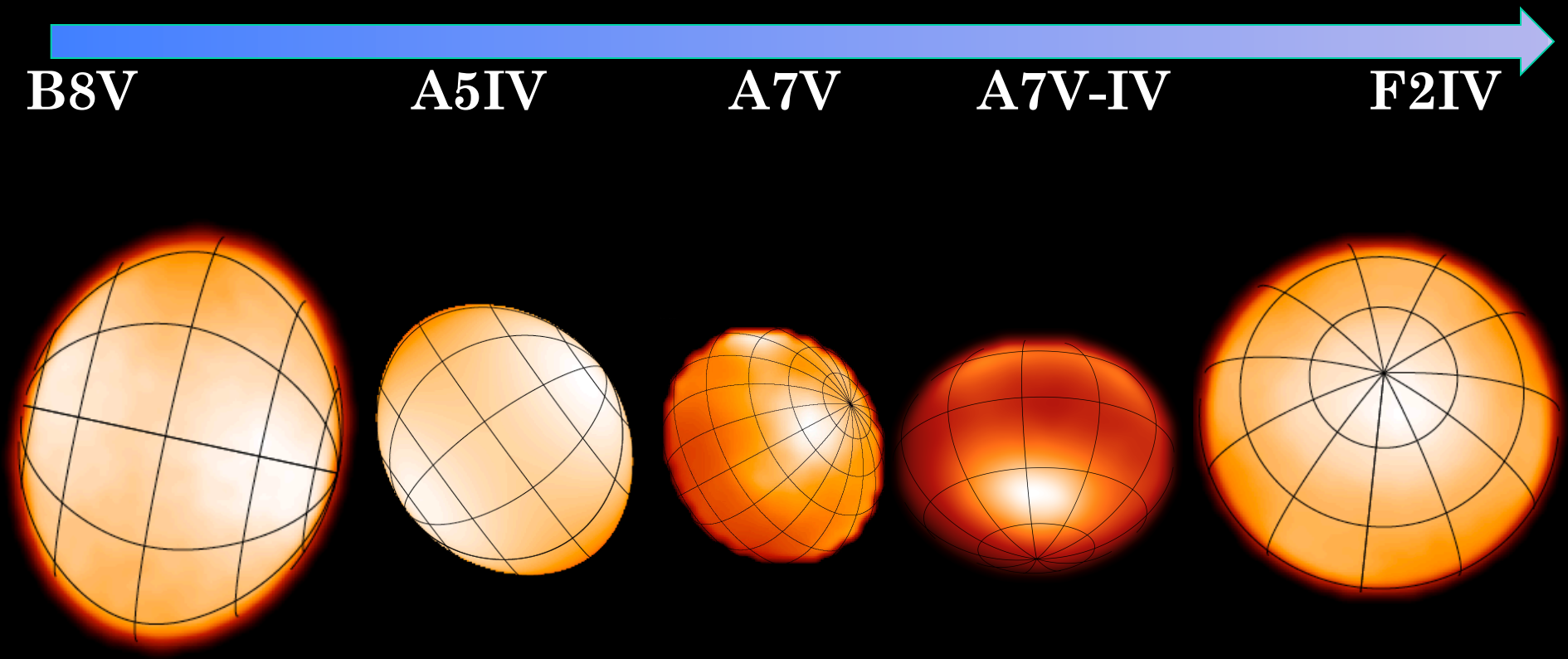
Measurements using the CHARA Array.
These data from 2009

First image of a main-sequence star
(besides the Sun…)

- Altair (a Aql, V=0.7)
  - Nearby hot star (d=5.1pc, SType A7V, T=7850 K)
  - Rapidly rotating (v sin i = 240 km/s, ~90% breakup)



MIRC Observations of Rapid Rotators



Regulus	Rasalhague	Altair	Alderamin	Bet Cas
Che et al. 2011	Zhao et al. 2009	Monnier et al. 2007	Zhao et al. 2009	Che et al. 2011

from recent review by Ming Zhao

2 R_{sun}

Imaging spots is hard because the dynamic range is large.

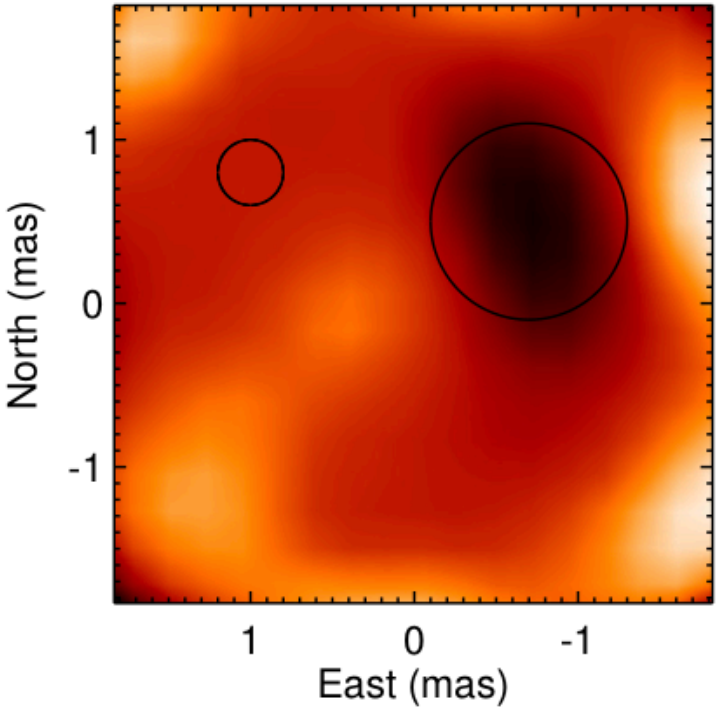


Figure 10. diameters e

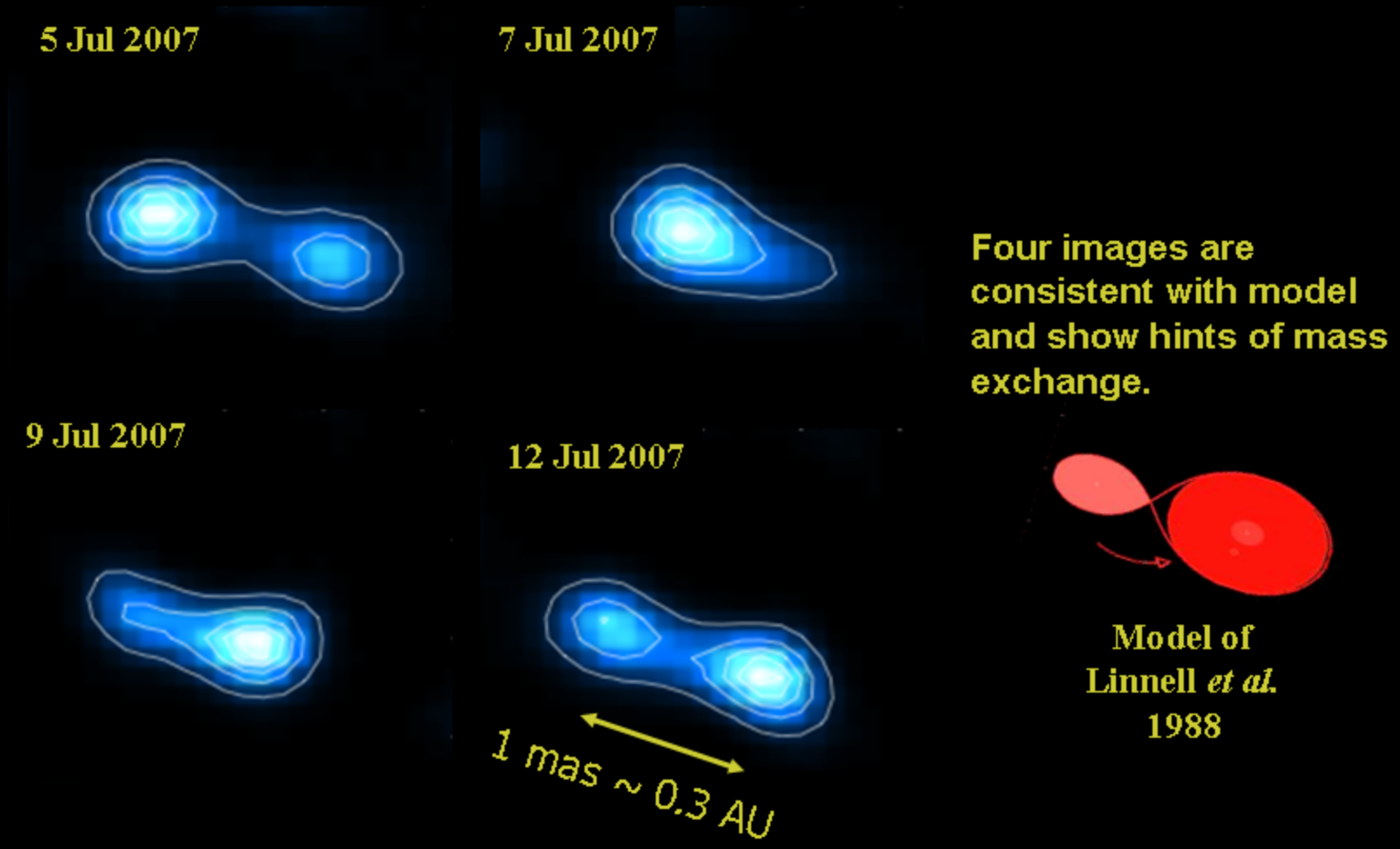
ngular

FIG. 2.— Shown is a closeup of the SQUEEZE reconstruction for the Sep 2^{th}, 2011 data near an apparent starspot. The black circle on the right shows the aperture used to extract starspot properties from reconstructed image. The black circle on the left shows the aperture over the "quiet" photosphere. The "quiet" photosphere is defined as a part of the stellar surface devoid of flux gradients. The size of the aperture is identical to the minimum achievable angular resolution.

Parks et al. 2015

βLyrae – First Imagery: 4-frame movie

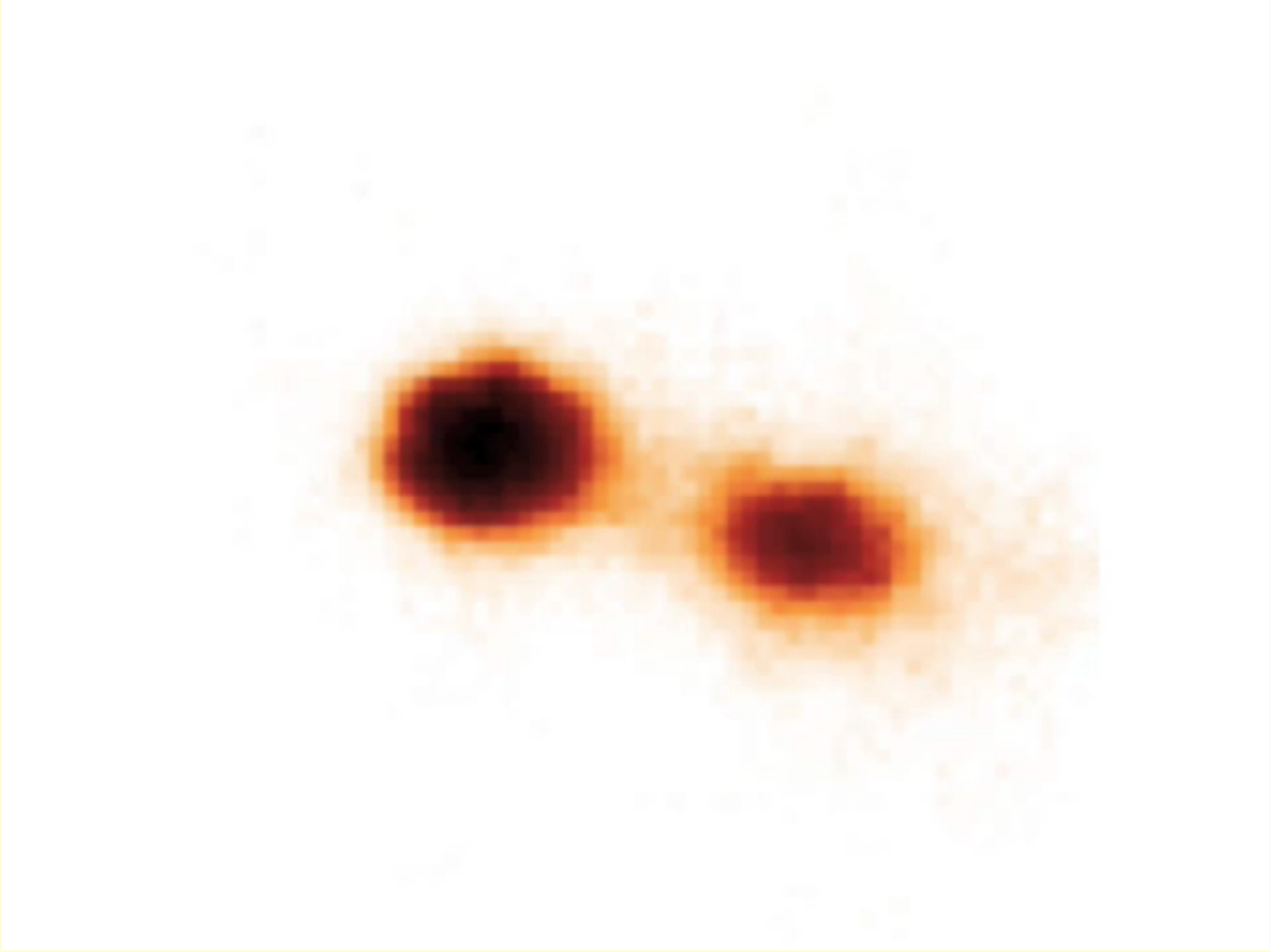
Zhao et al. Science 2007.



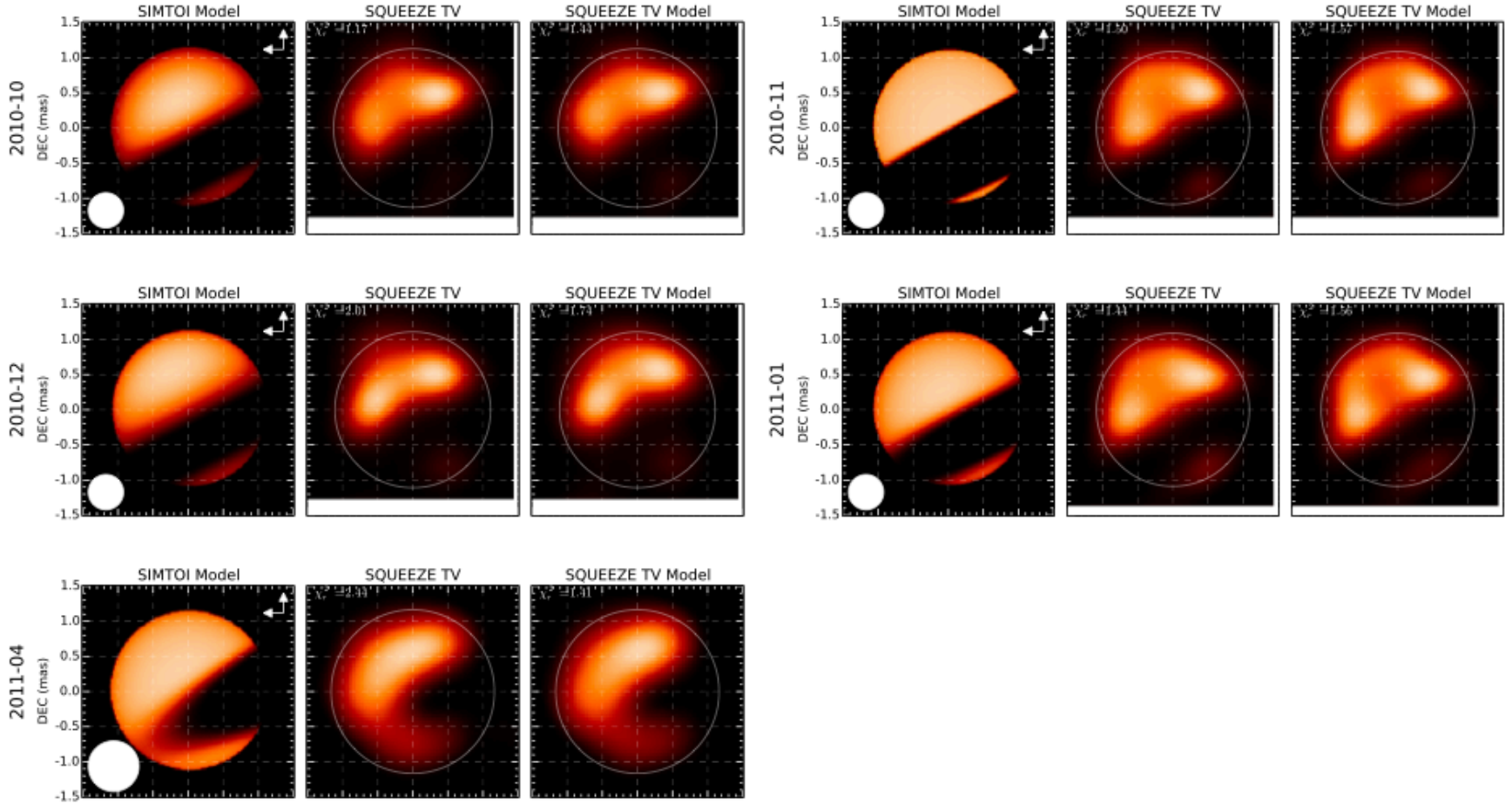
Four images are consistent with model and show hints of mass exchange.

Model of Linnell *et al.* 1988

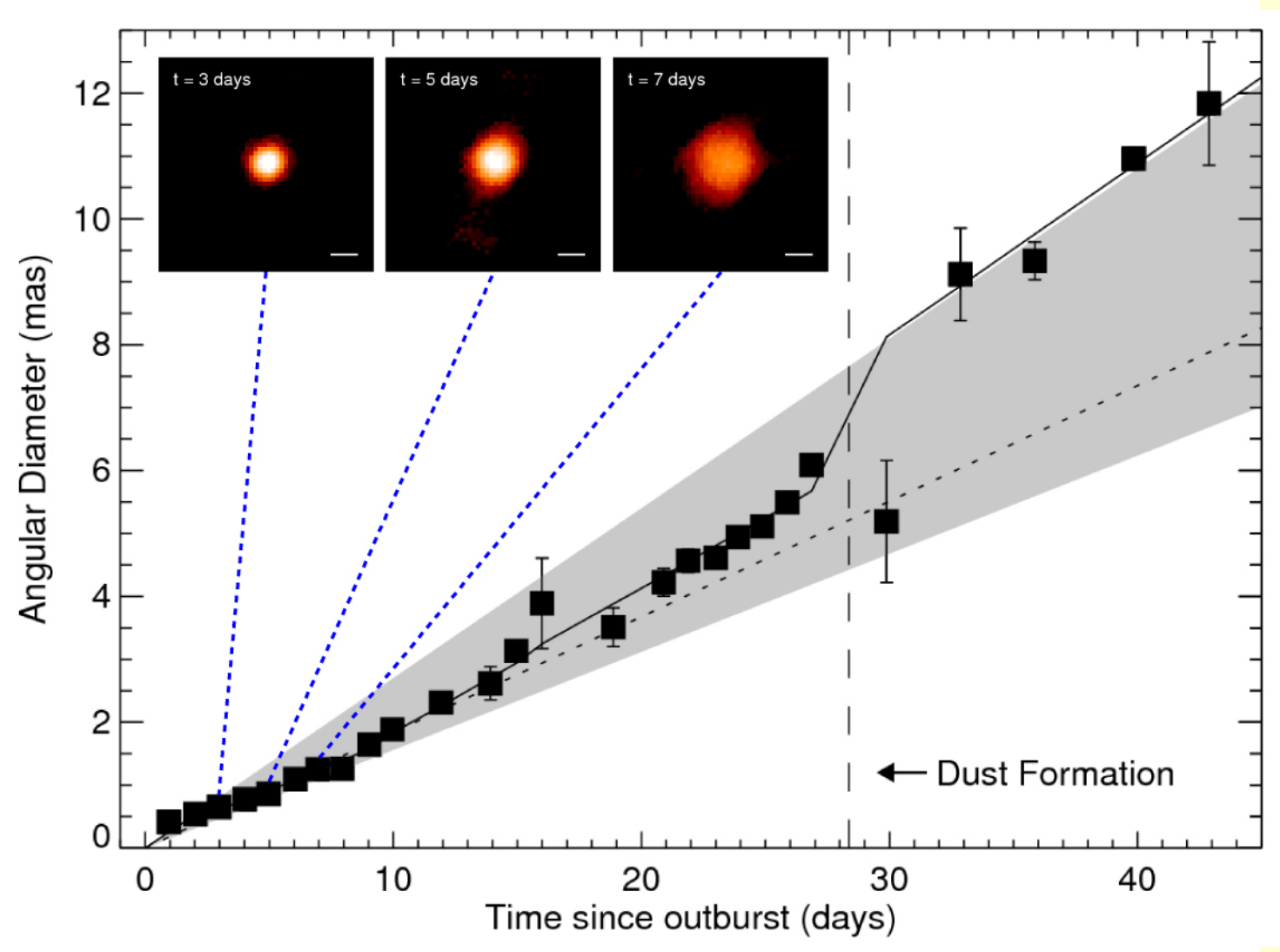
β Lyrae – The Movie



Eps Aur – The Images *Kloppenborg et al.* Nature *2010.*



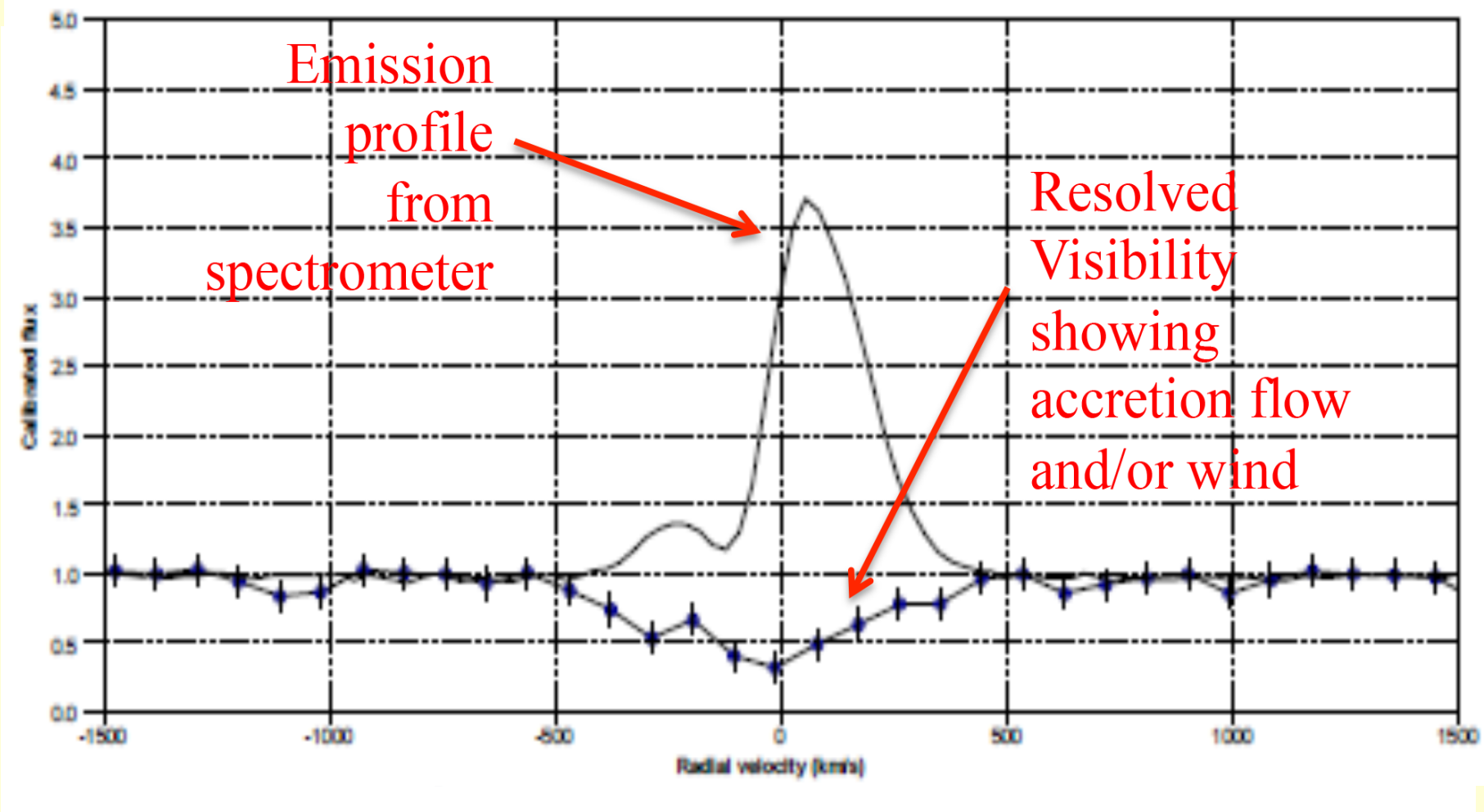
The expanding fireball of nova Delphini 2014 *Schaefer et al* Nature *2014*



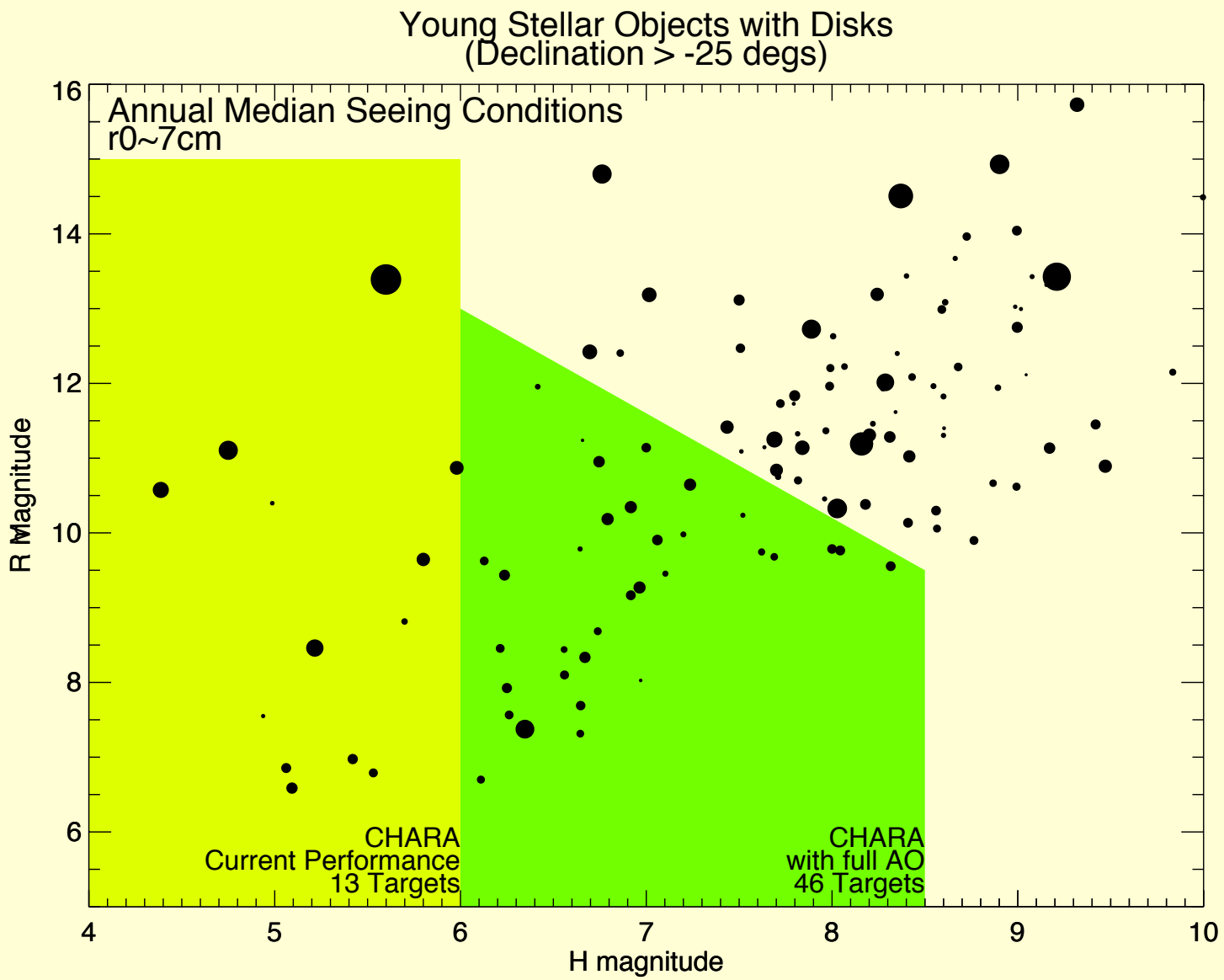
CHARA-AO Program

- The CHARA Adaptive Optics Program is broken into 2 Phases.
- This is purely an artifact of funding realities.
- Phase I, which includes Wavefront Sensors for each telescope and non-common-path AO systems for the laboratory, was funded in 2010 and is now nearing completion.
- Phase II, which includes deformable mirrors for each telescope, should begin later this year.
- The program (as of two weeks ago) is fully funded.

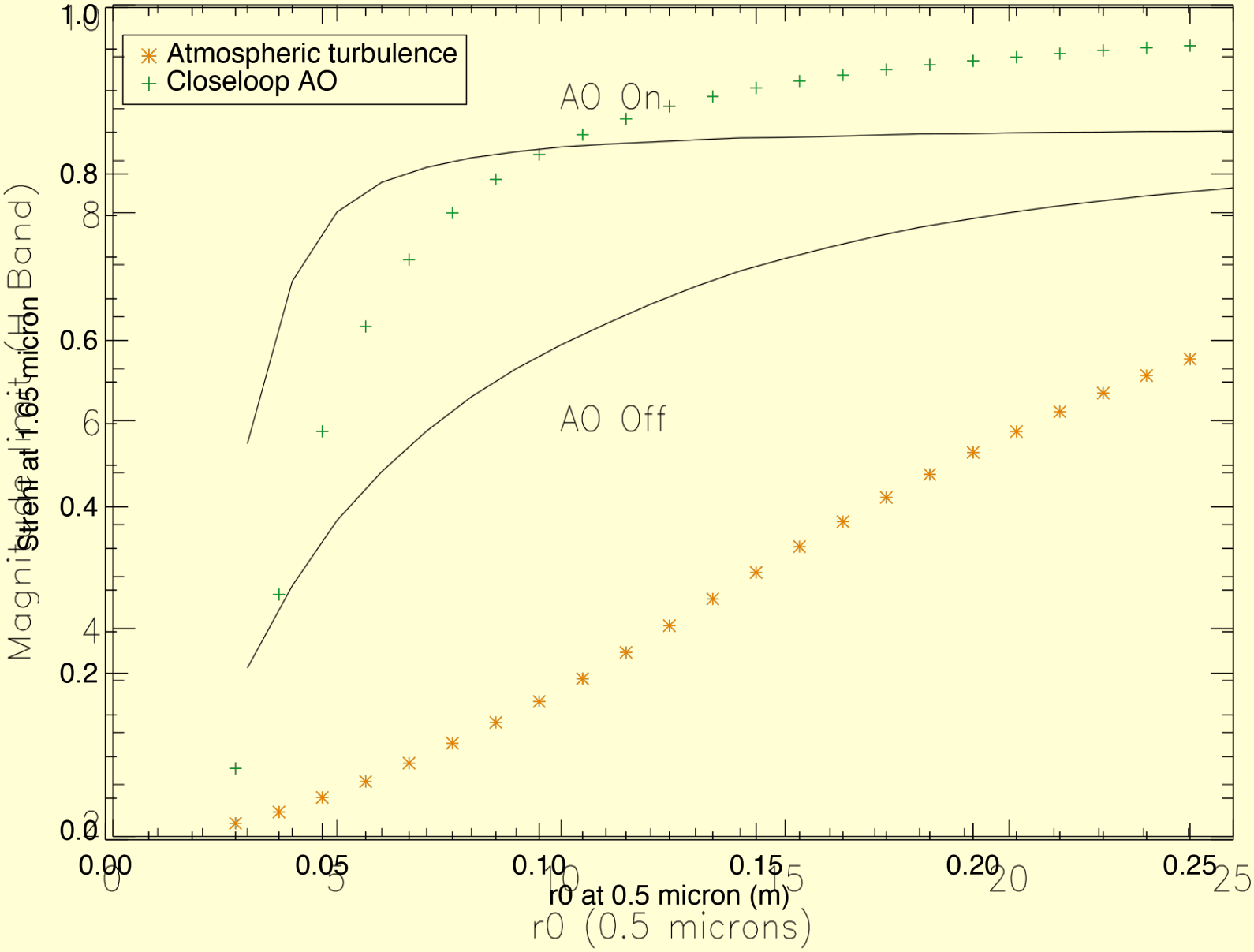
CHARA-AO Program – Science Rational



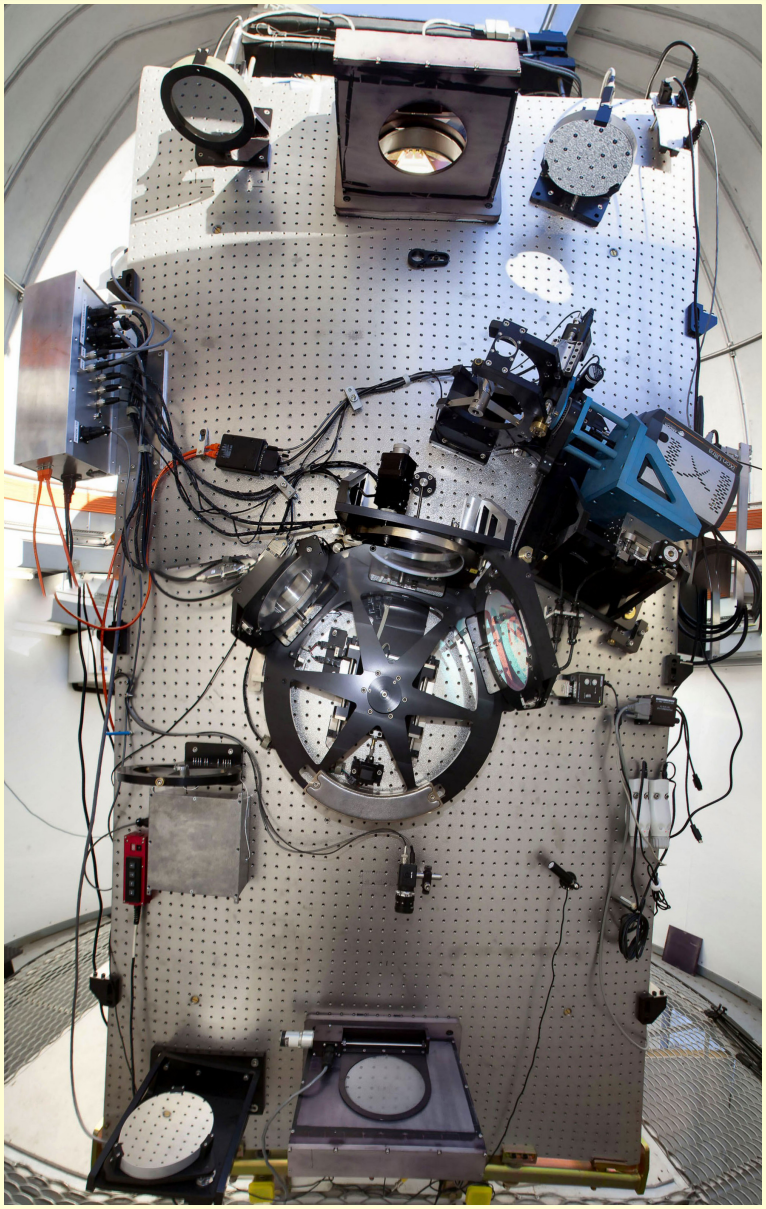
CHARA-AO Program – New Capabilities

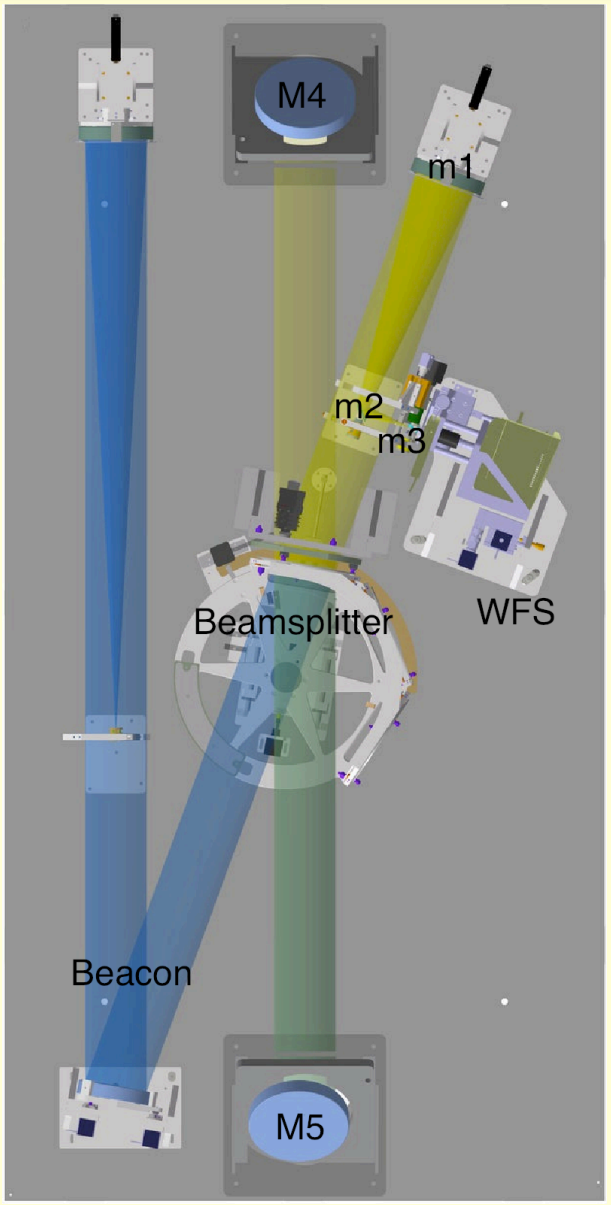


CHARA-AO Program – Science Rational

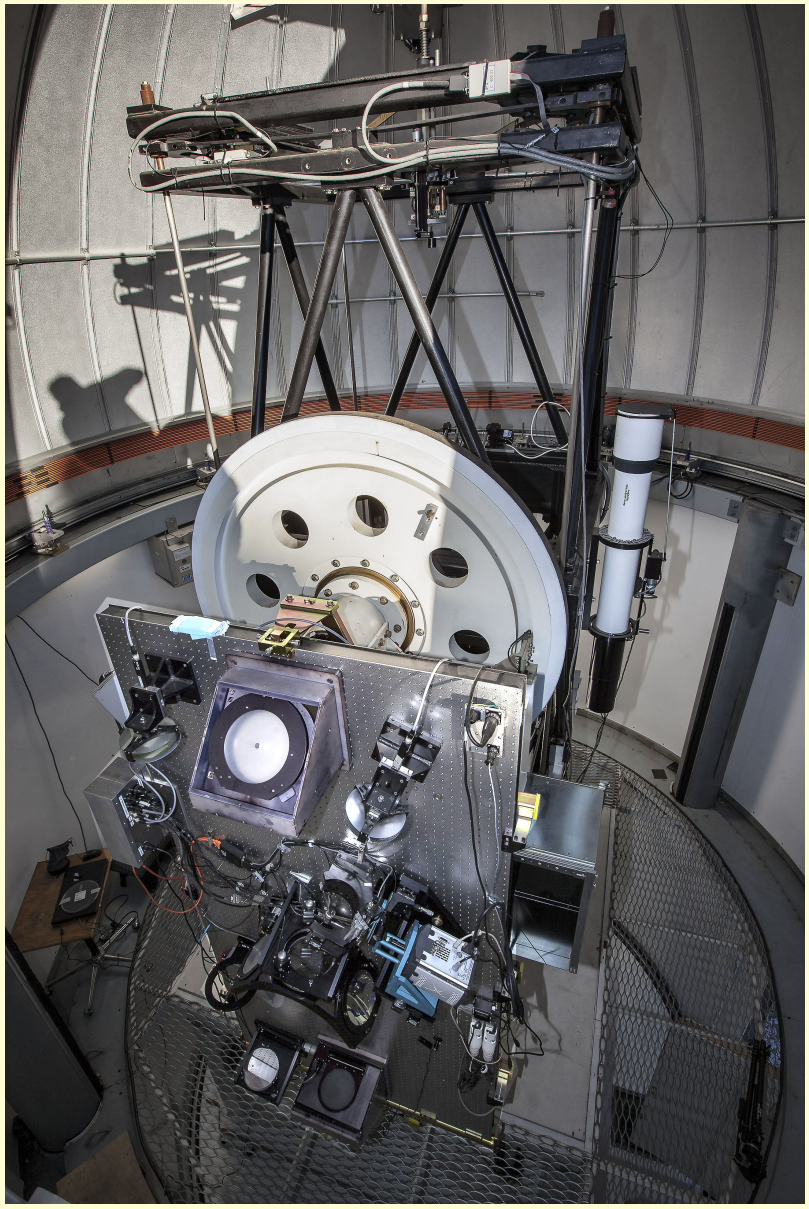


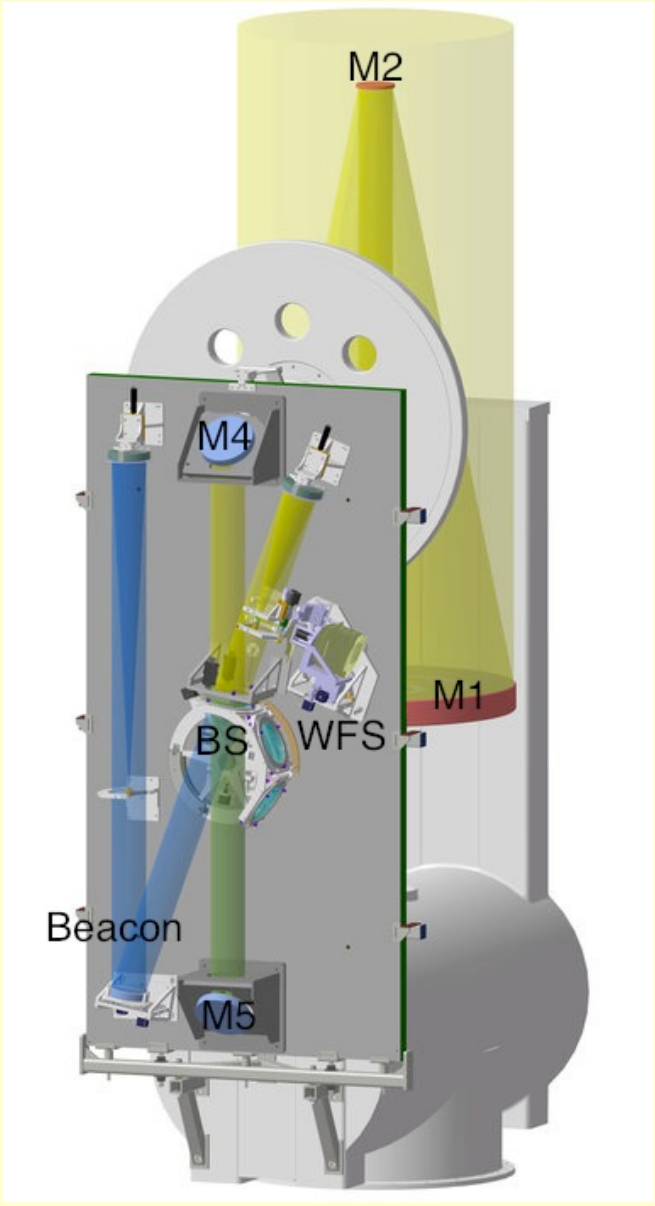
CHARA-AO Program – Telescope WFS



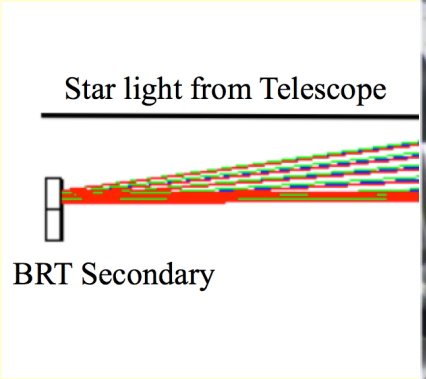


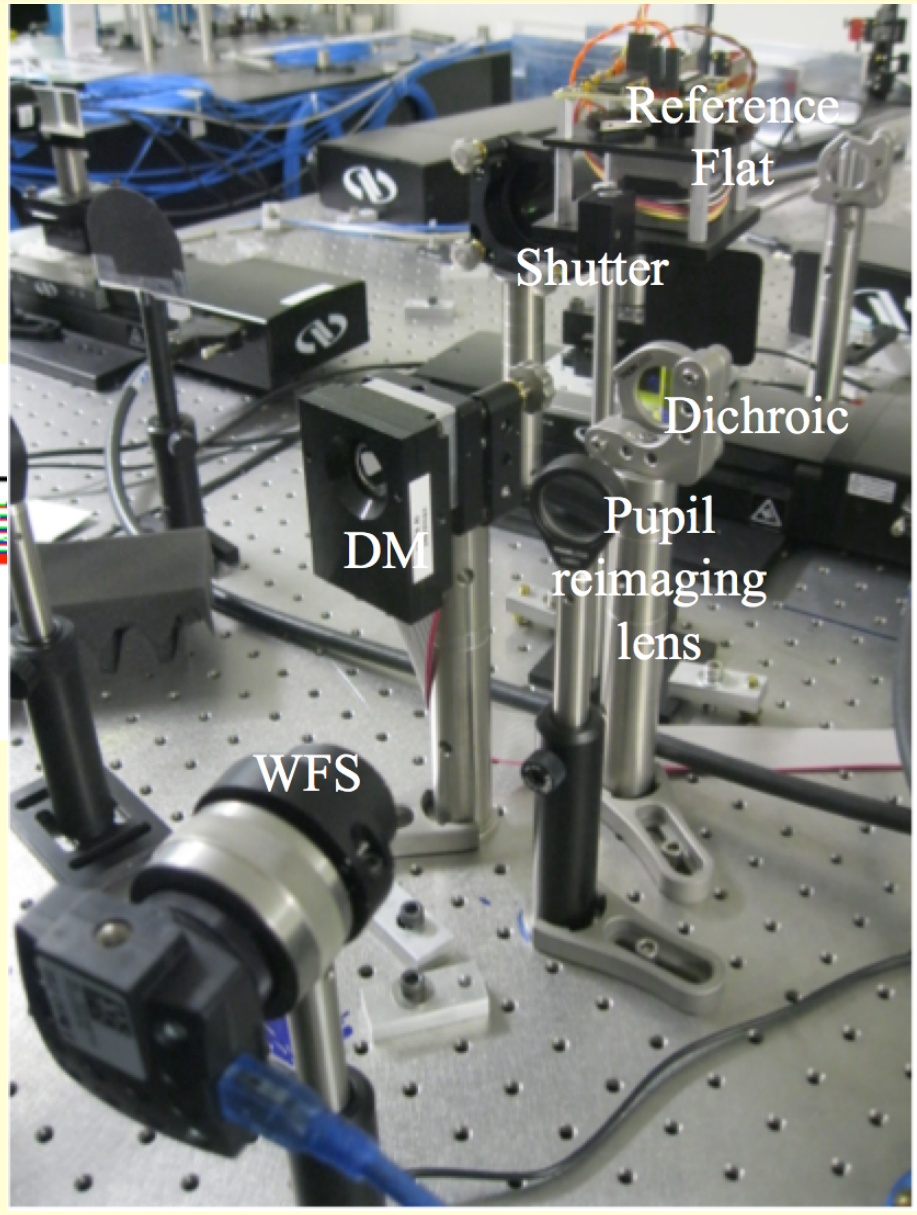
CHARA-AO Program – Telescope WFS

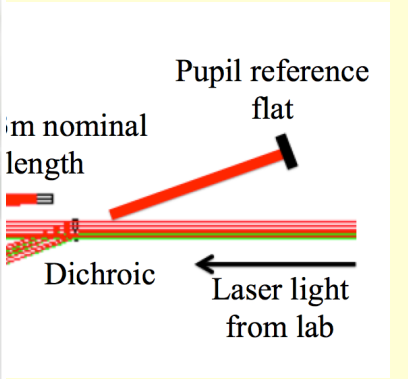




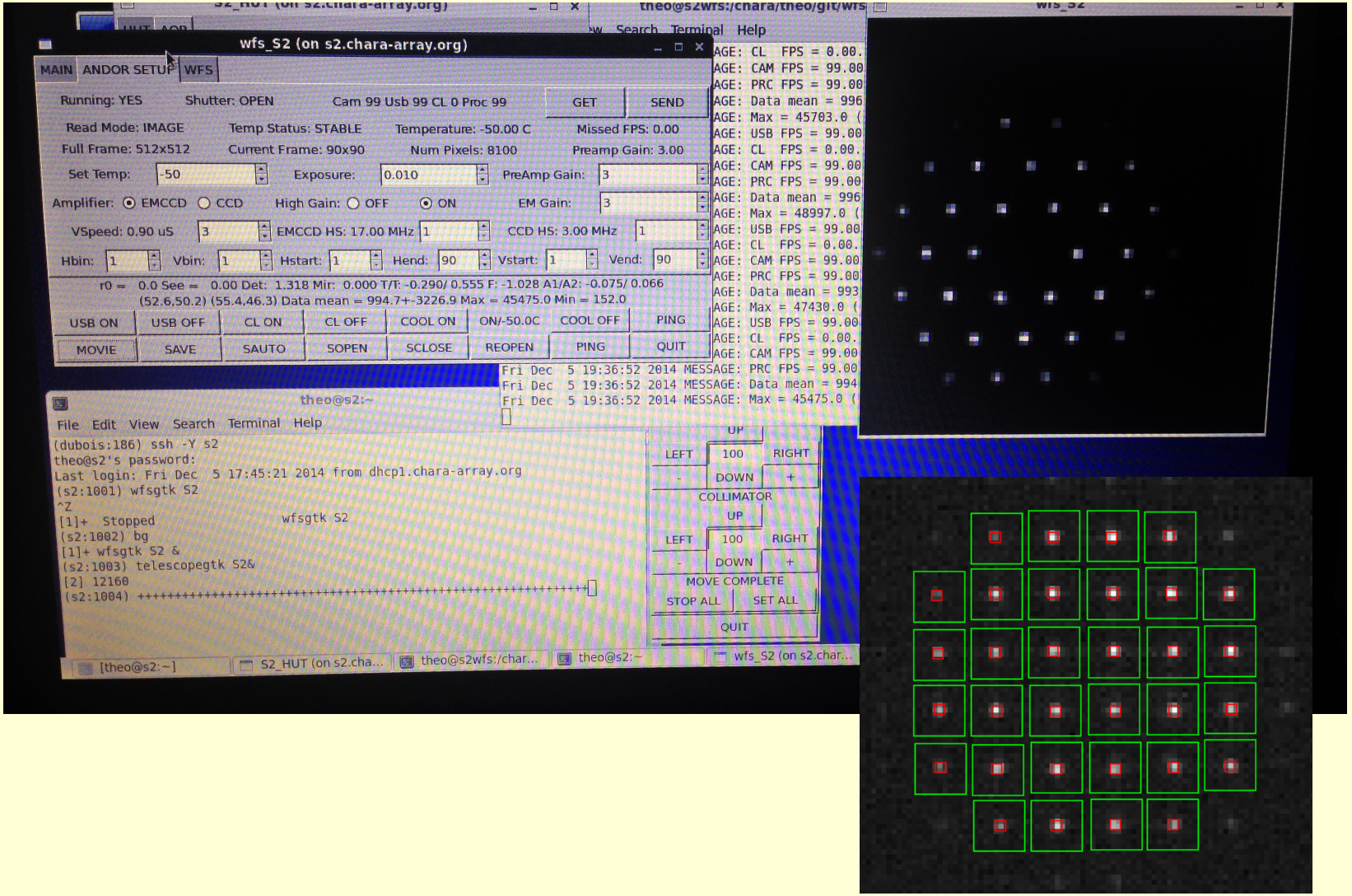
CHARA-AO Program – Lab AO



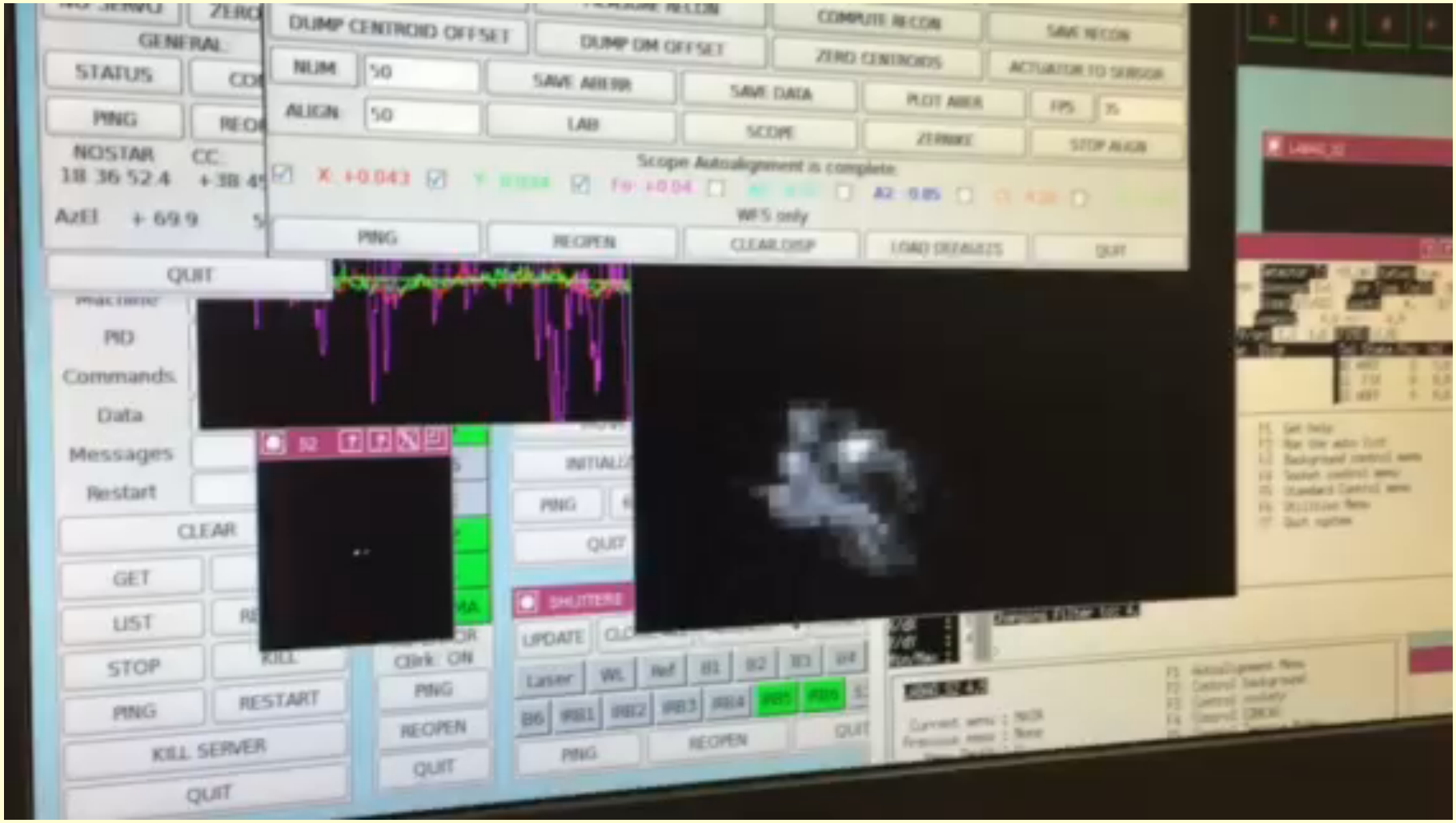




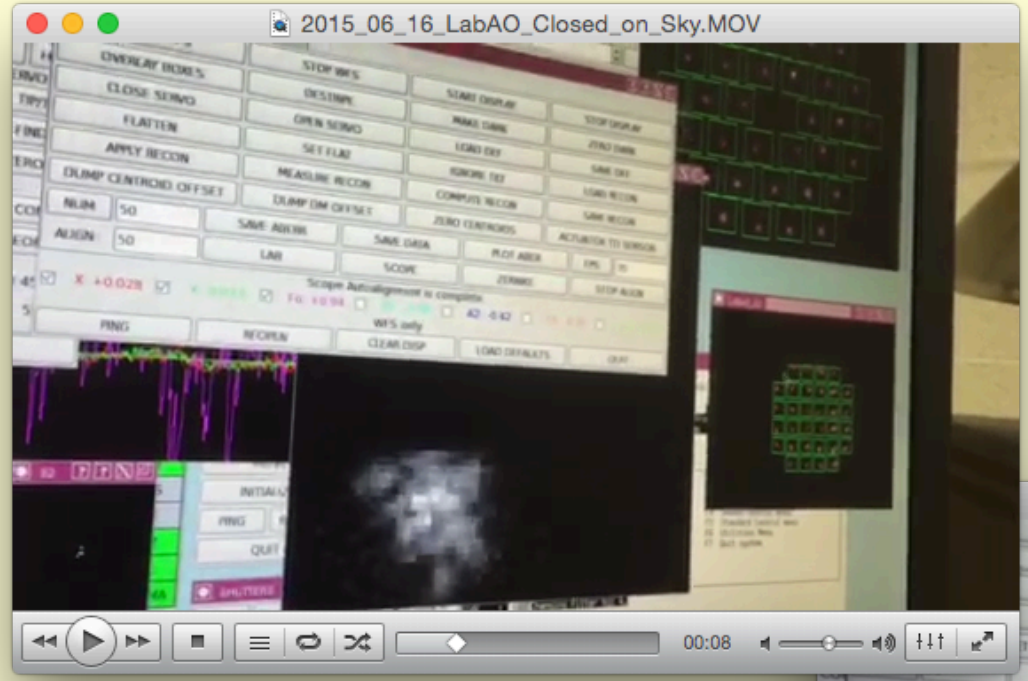
CHARA-AO Program – Software

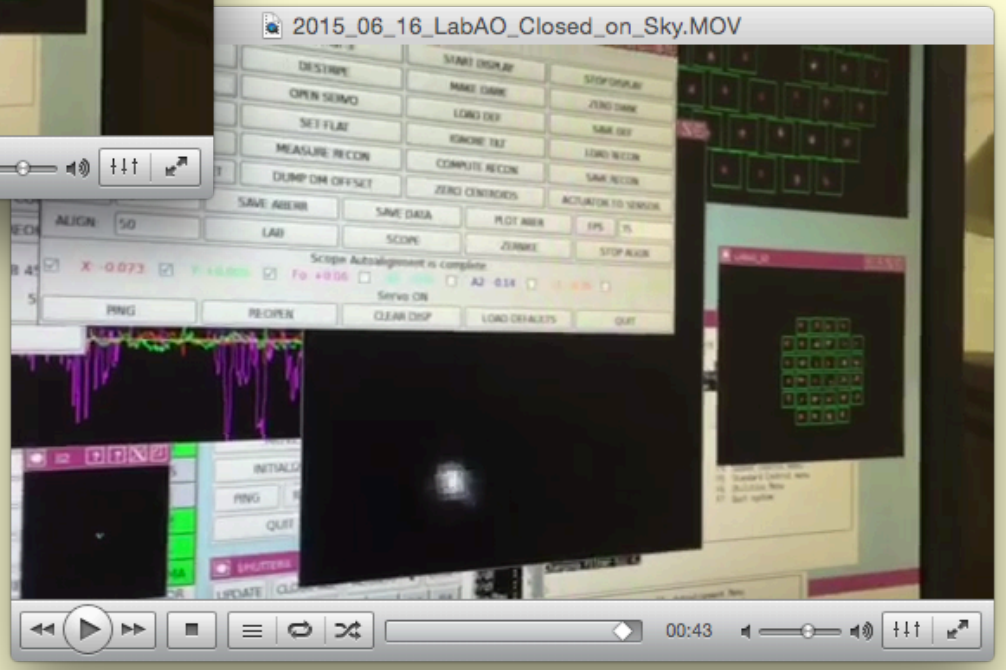


CHARA-AO Program – Does it Work?

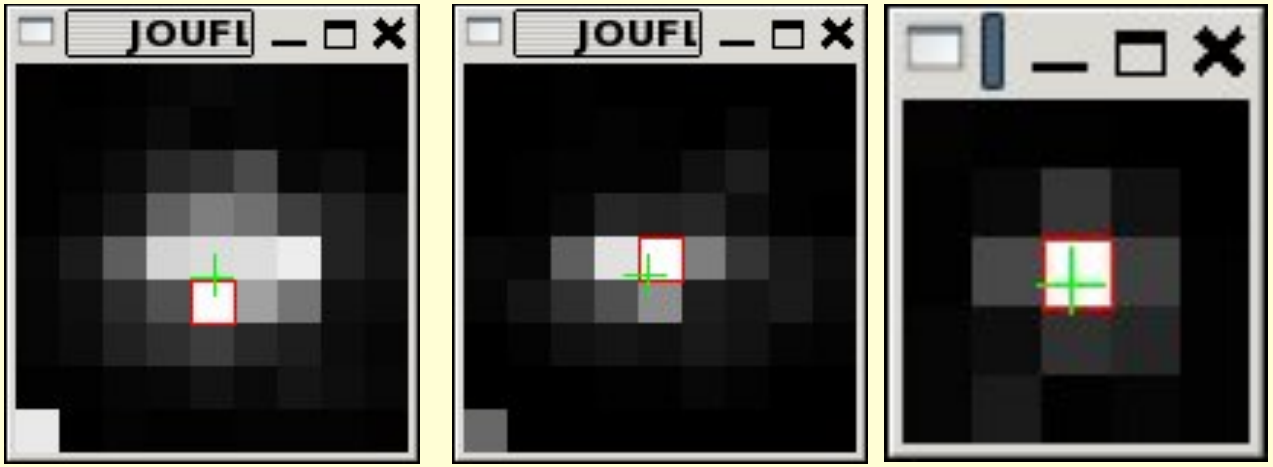


CHARA-AO Program – Does it Work?



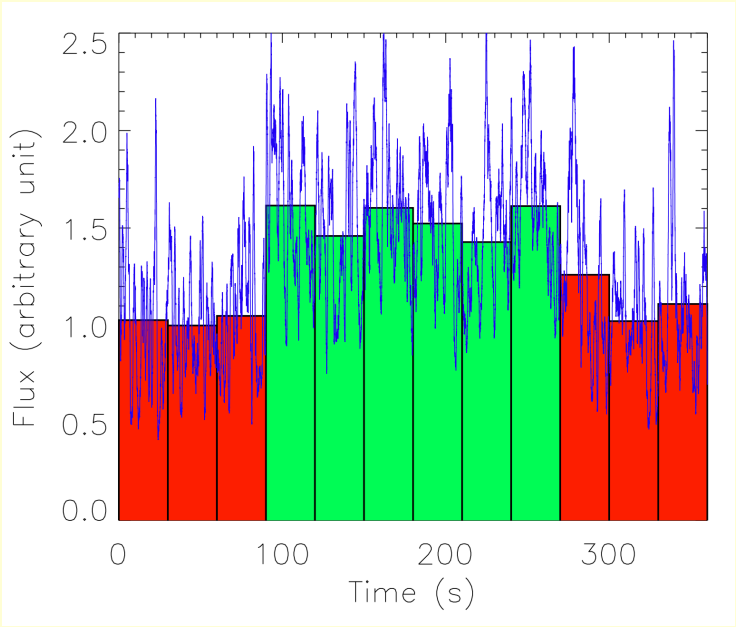


CHARA-AO Program – Does it Work?



K Band Light (2.3μm)

Fiber Raster Scan using FLUOR. Fiber is single mode in K band.
Left: AO Off.
Right AO ON



V Light Beam Combiner FRIEND

Fibers are singlemode in visible band.
Red: AO Off.
Green: AO ON

CHARA-AO Program – Phase II

- All results so far use Phase-I AO only.
- Just before this meeting we were told that Phase II, which will fund Deformable Mirrors for each telescope, will be supported by the NSF.
- These DMs must be large and will replace M4 in the current optical path.
- $2.7M USD project.

Algol the Movie: Baron et al 2011.