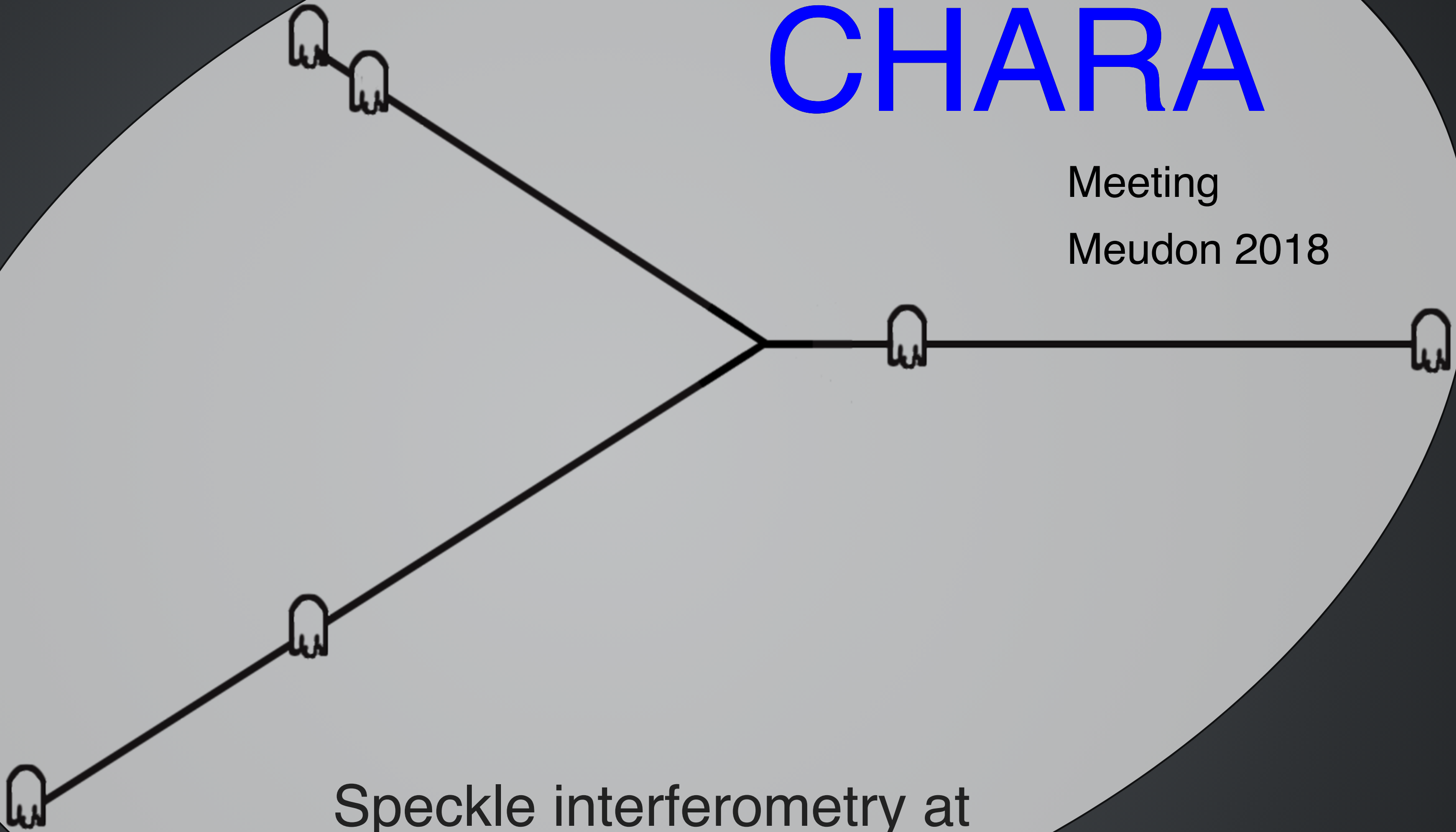
CHARA

Meeting

Meudon 2018



Speckle interferometry at NASA ARC

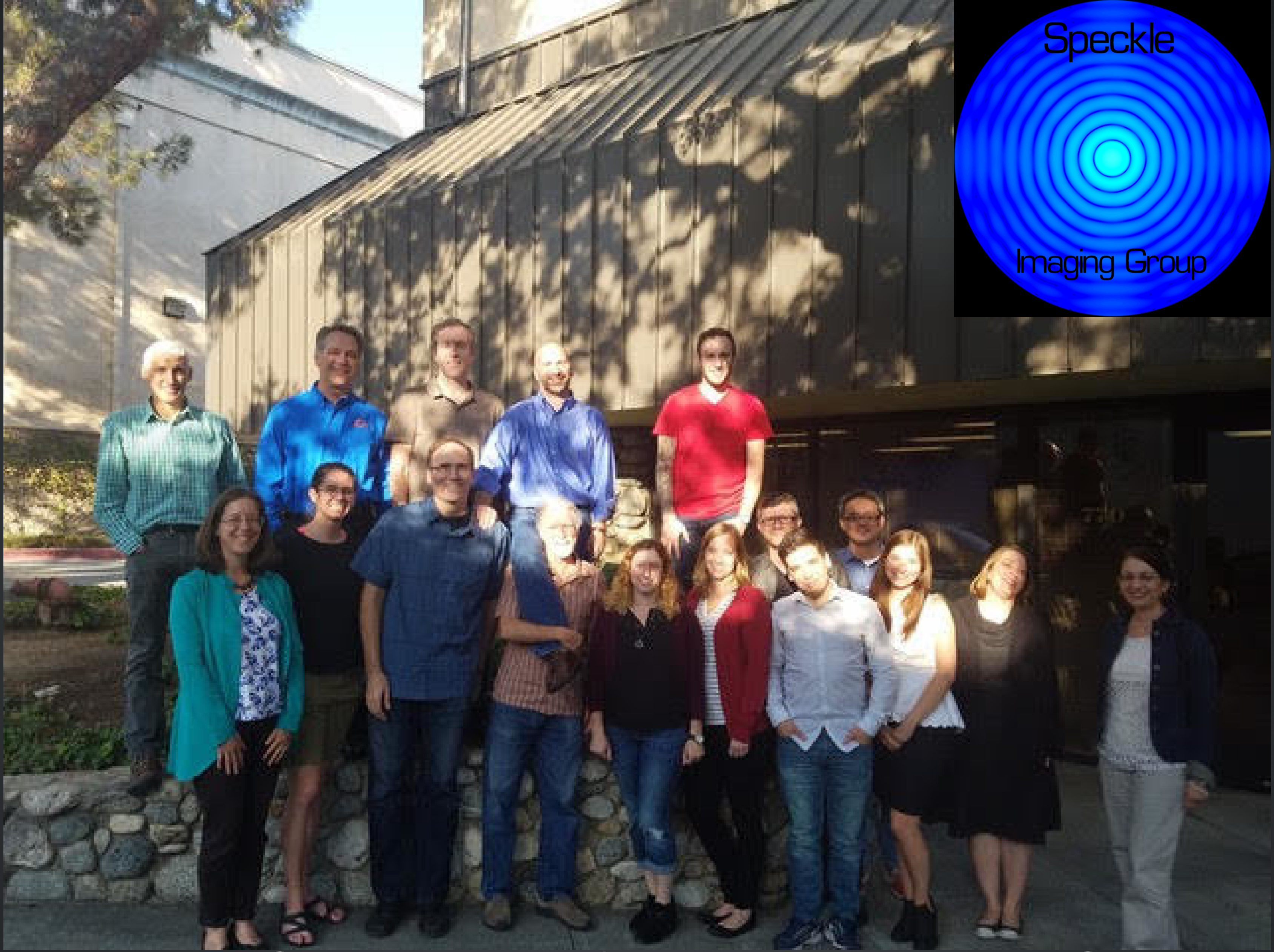
nic scott

NASA ARC

Speckle...

the once and future interferometry?

- Speckle Imaging Group
- Instruments
    - Past
        - DSSI
    - Present
        - NESSI
        - `Alopeke
    - Future
        - Zorro
        - QWISSI, SEXSI (Gerard)
- Techniques
    - Wide Field
    - Extended objects
- Projects



2018 Speckle retreat, following the "Know thy Stars. Know thy Planet" meeting

DSSI


Author network
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Everett, M
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DSSI Speckle Team
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Xie, J
Hillenbrand, L
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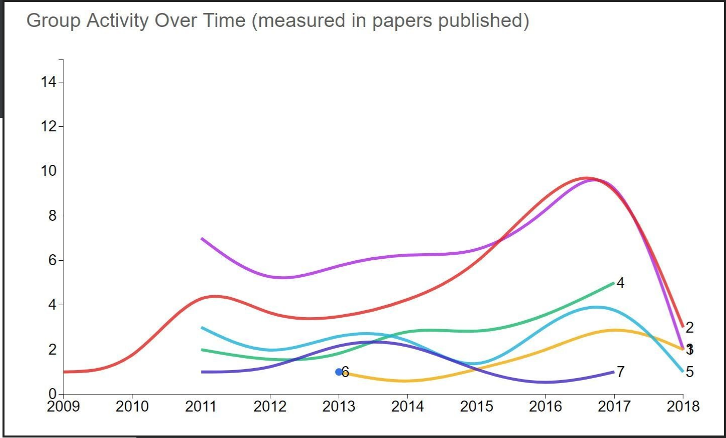
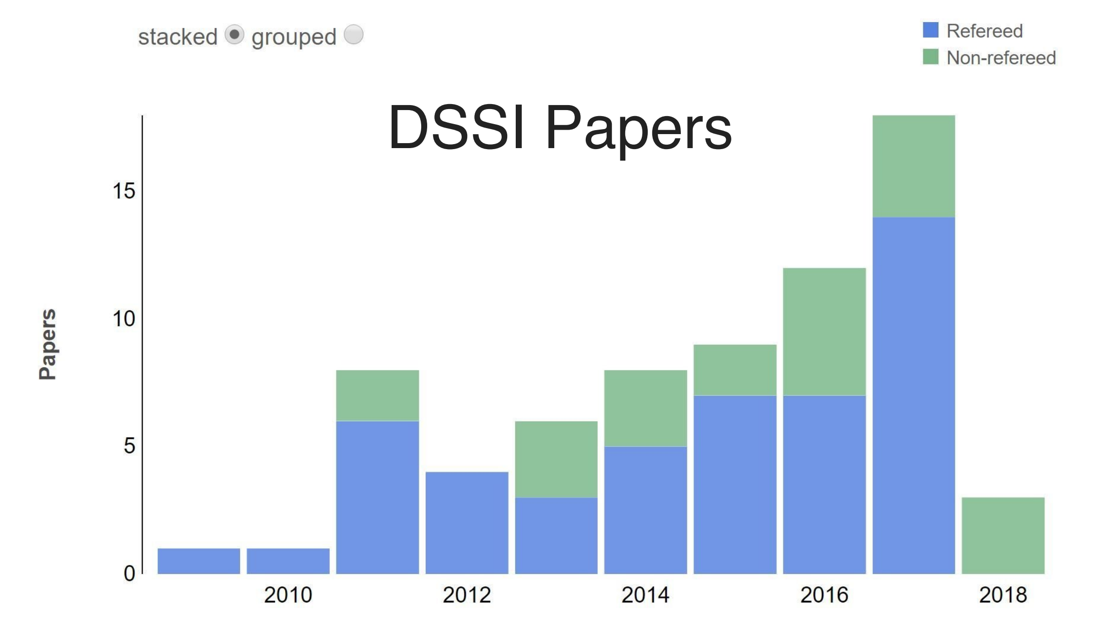
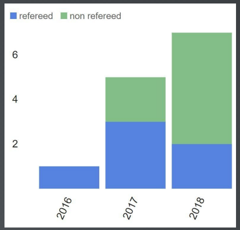
Charbonneau, D
Liu, M
Carpenter, J
Isaacson, H
Petigura, E
Fulton, B
Sinukoff, E
Crossfield, I
Schlieder, J
Weiss, L
Grundy, W
Young, L
Young, E
Buie, M
Fischer, D


Group Activity Over Time (measured in papers published)
14
12
10
8
6
4
2
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
4
6
7
2
3
5

DSSI Papers

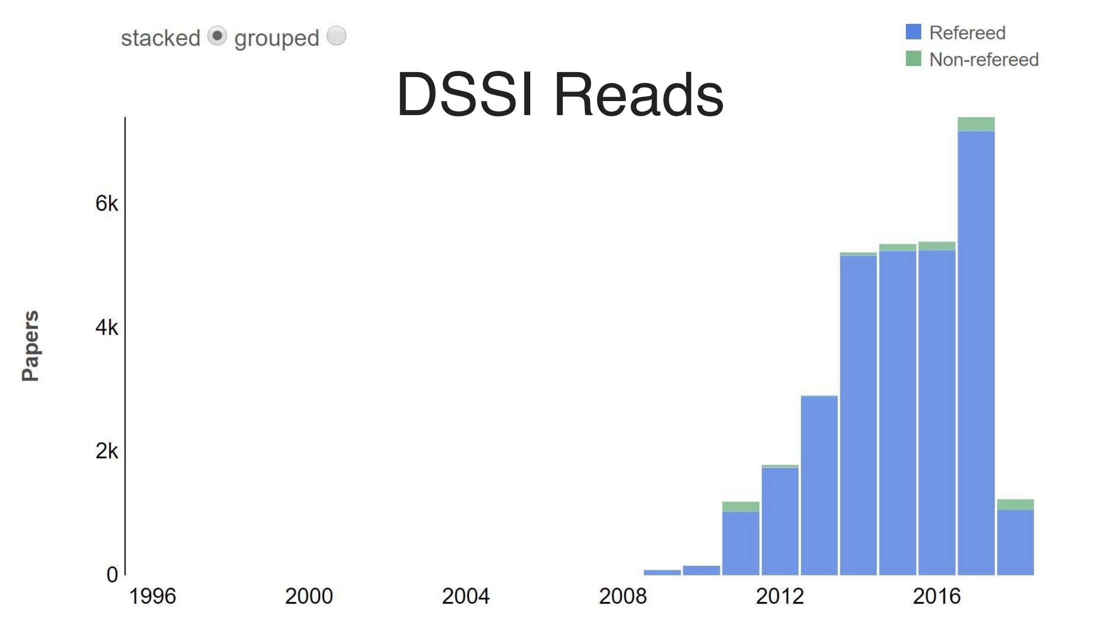


NESSI papers

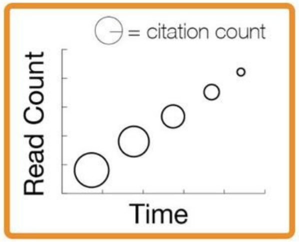


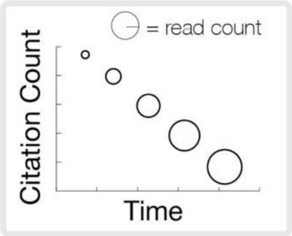
		Totals	Refereed
Total number of reads	?	1276	845
Average number of reads	?	116	211.3
Median number of reads	?	67	236
Total number of downloads	?	685	472
Average number of downloads	?	62.3	118
Median number of downloads	?	25	25

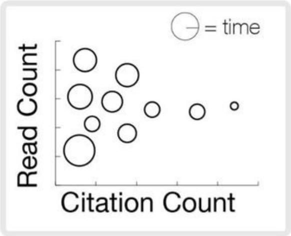
DSSI Reads

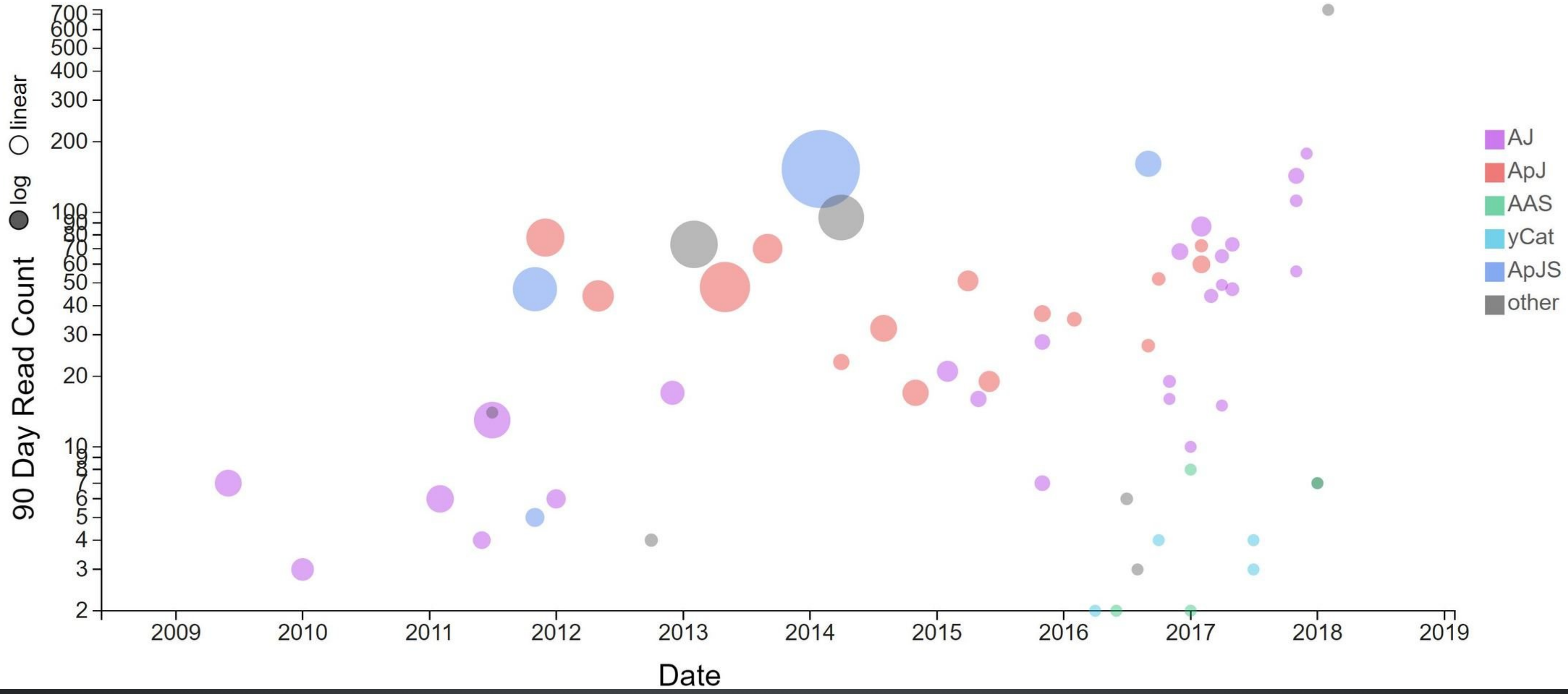


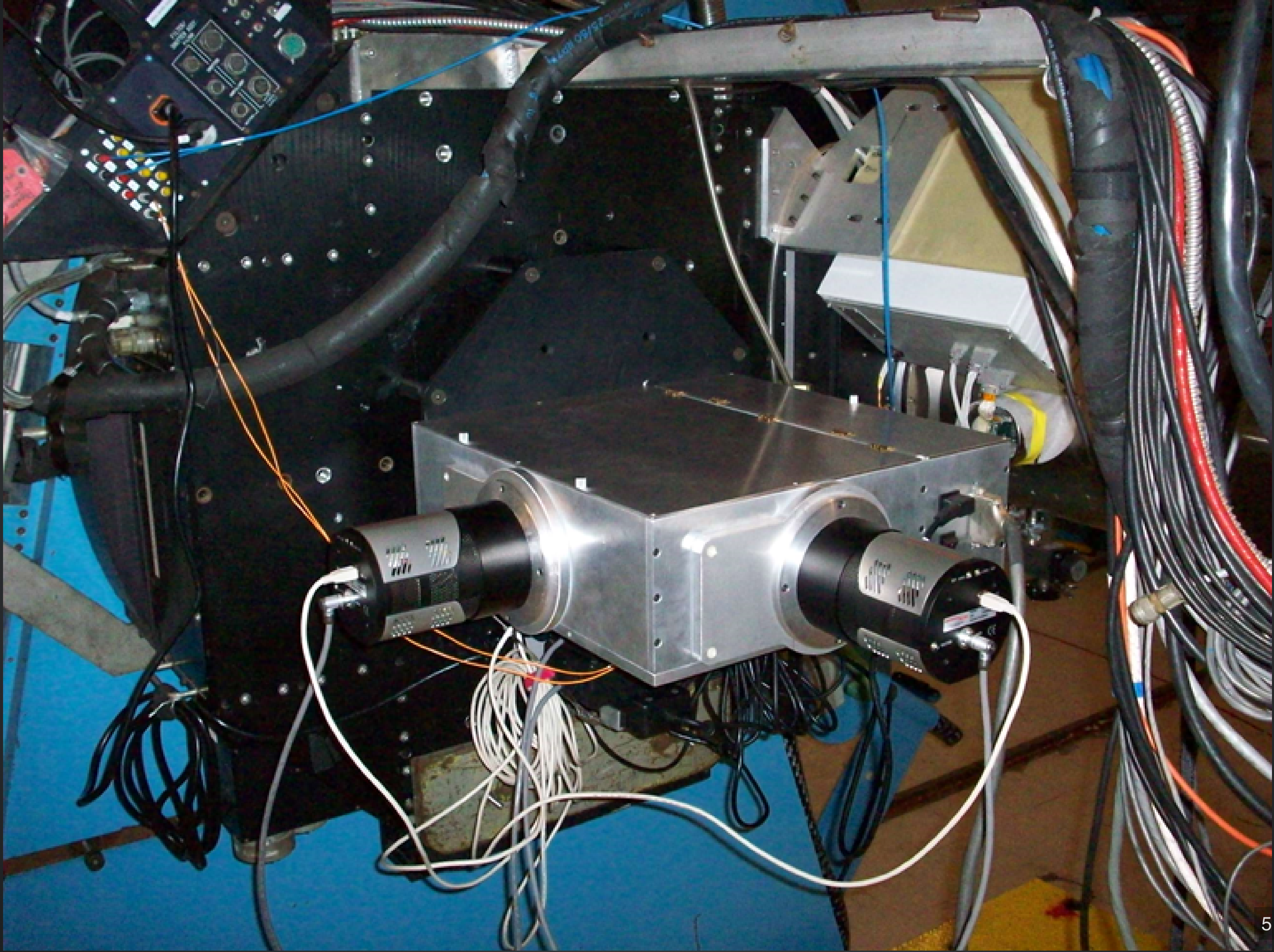
		Totals	Refereed
Total number of reads	?	30729	29785
Average number of reads	?	445.3	620.5
Median number of reads	?	275	409
Total number of downloads	?	15627	15391
Average number of downloads	?	226.5	320.6
Median number of downloads	?	144	144

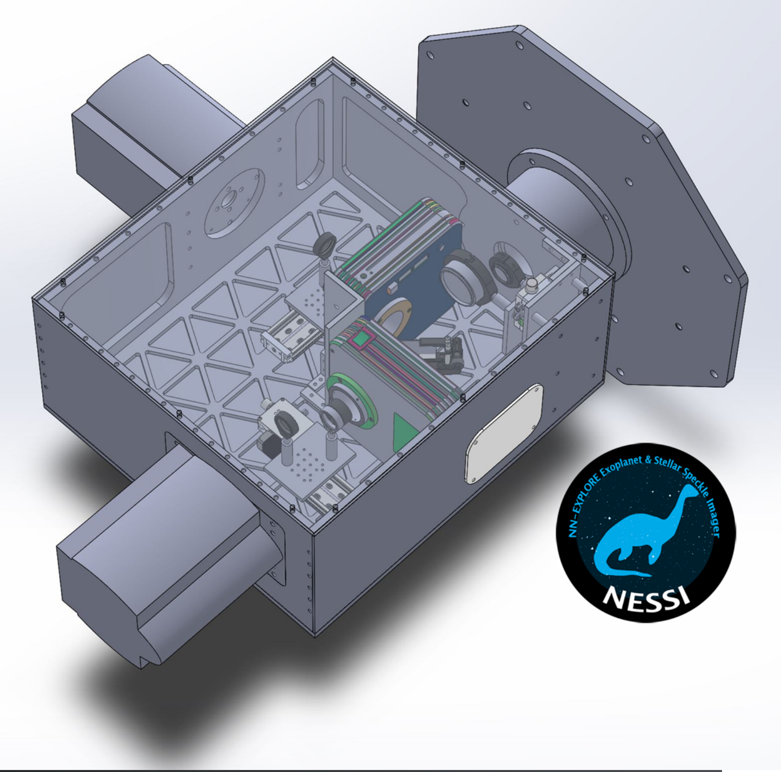

= citation count
Read Count
Time

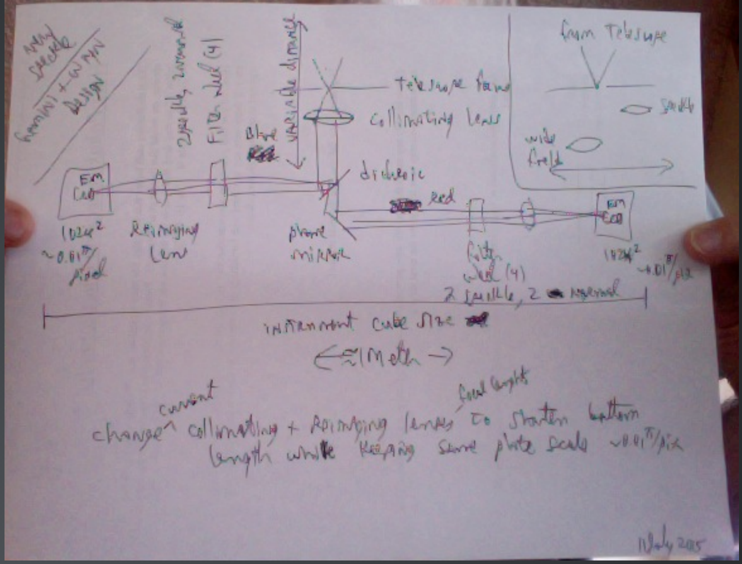

= read count
Citation Count
Time

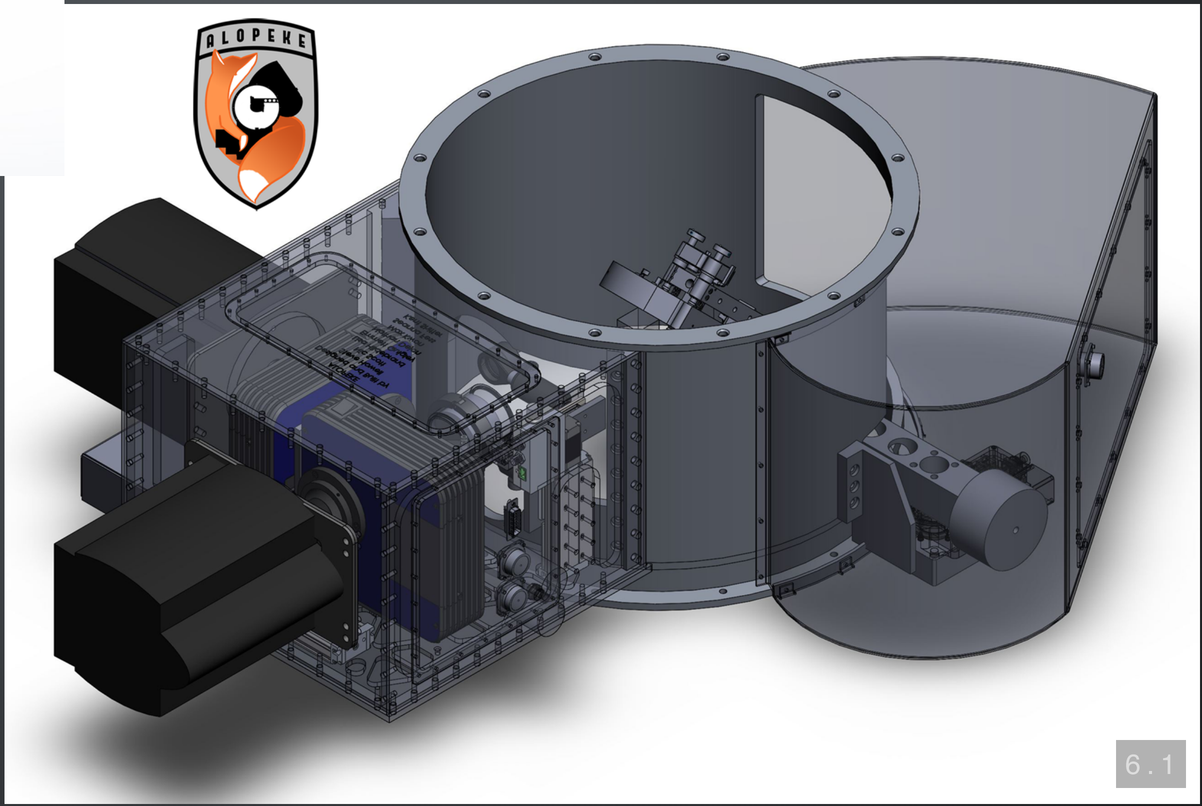

= time
Read Count
Citation Count


log
linear
90 Day Read Count
Date
AJ
ApJ
AAS
yCat
ApJS
other




NN-EXPLORE Exoplanet & Stellar Speckle Imager
NESSI


from Telescope
speckle
wide field
collimating lens
dichroic
red
EM CCD
Reimaging lens
instrument cube size
change current collimating + reimaging lenses focal length to shorten bottom length while keeping same plate scale

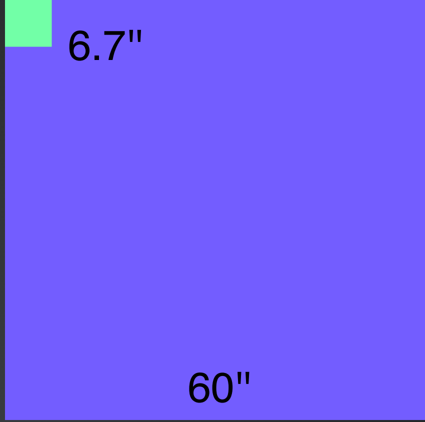

ALOPEKE

Speckle

- 10mas/pxl
- mag limit ~17
- contrast limit ~8

Wide Field

- 73mas/pxl



0.011" @u

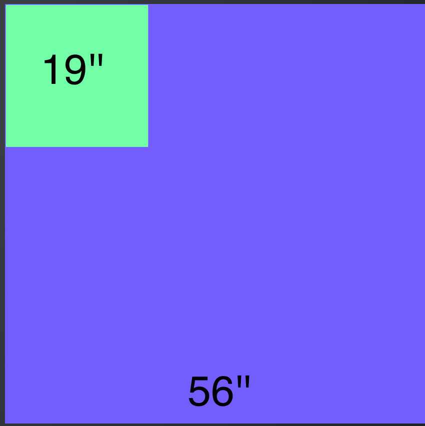
0.026" @832nm

Speckle

- 18mas/pxl
- mag limit ~14
- contrast limit ~6

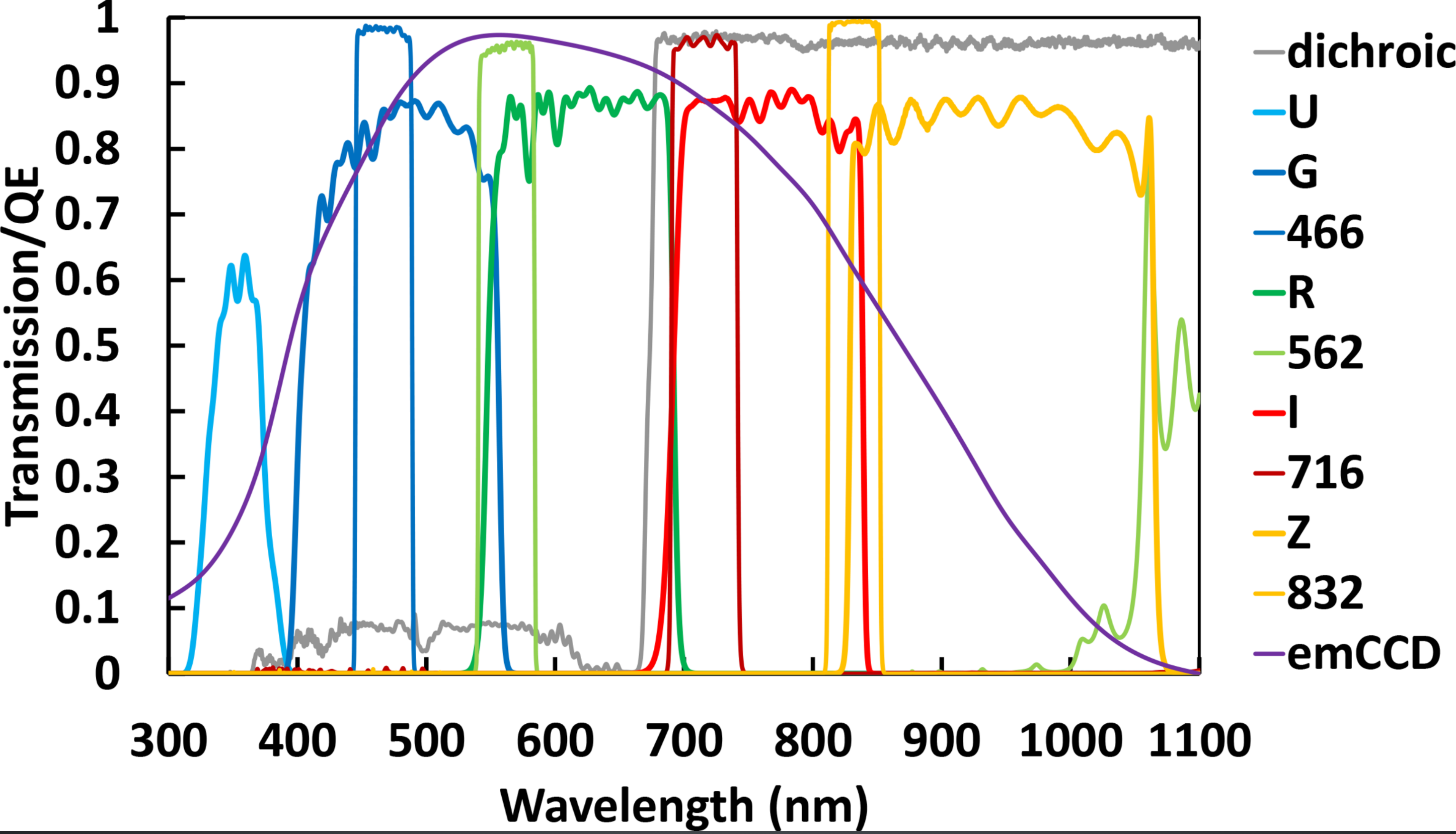
Wide Field

- 81mas/pxl

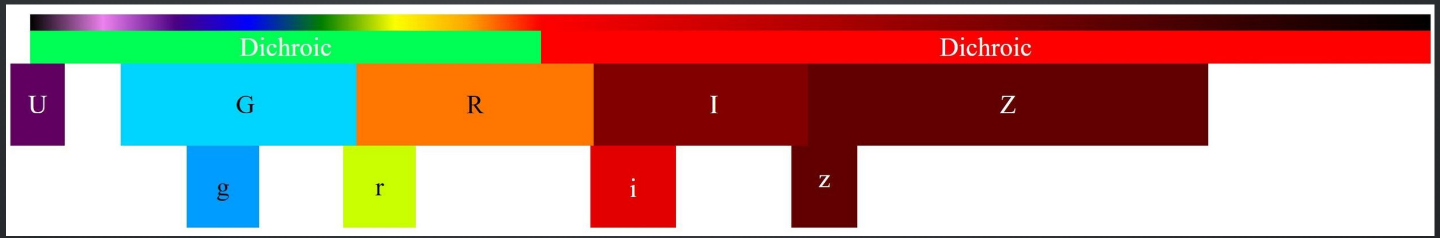


0.025" @u

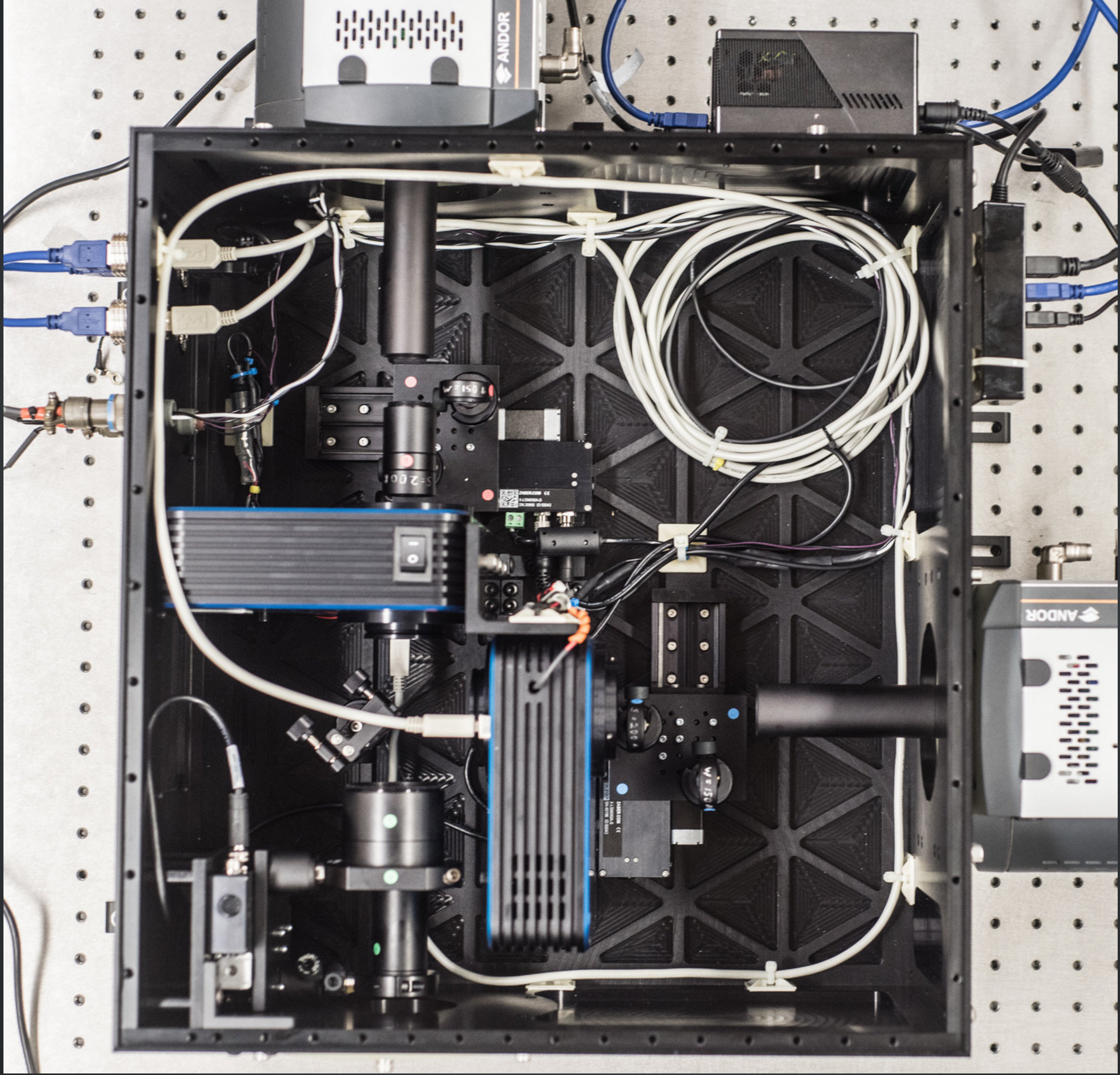
0.060" @832nm

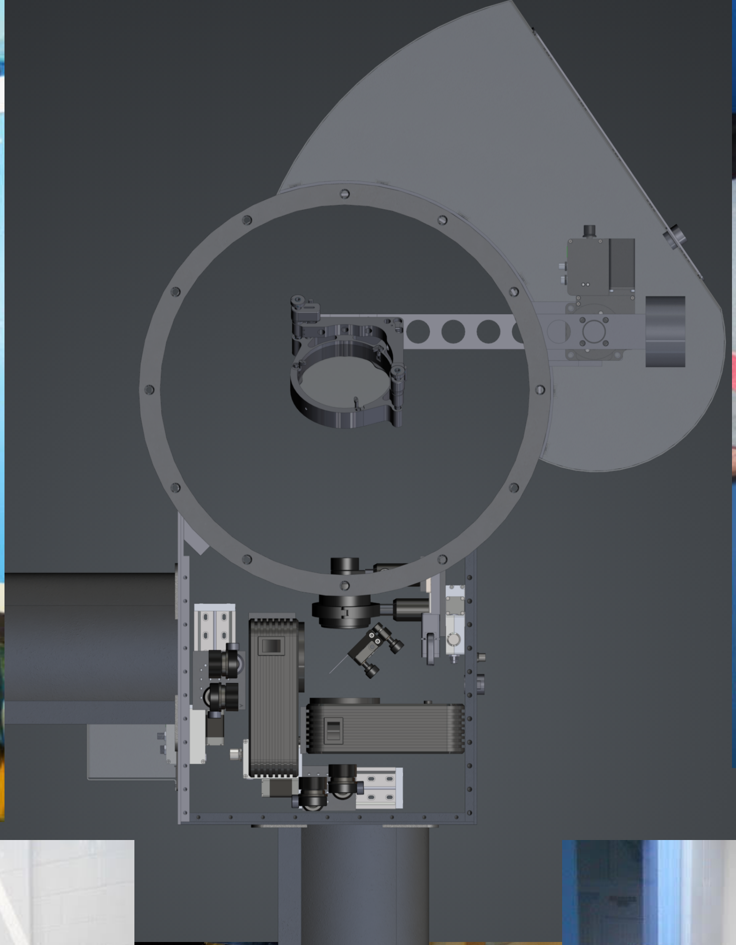


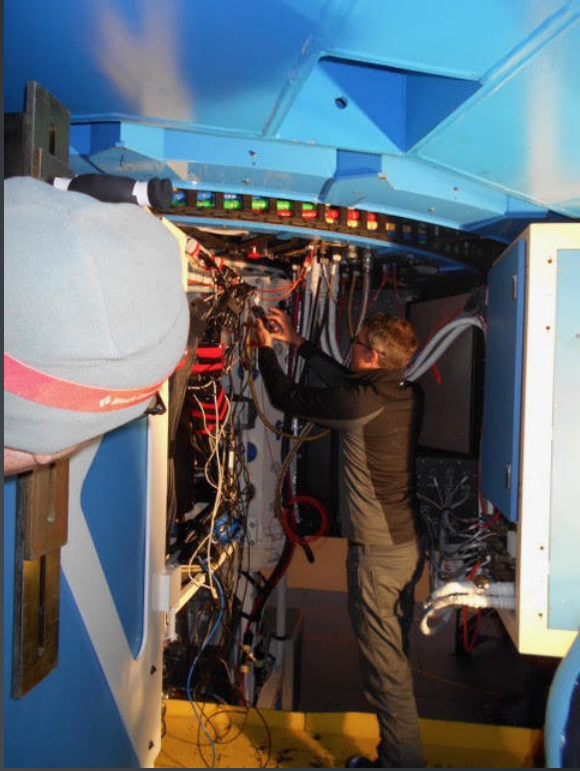
Transmission/QE
Wavelength (nm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
300
400
500
600
700
800
900
1000
1100
dichroic
U
G
466
R
562
I
716
Z
832
emCCD

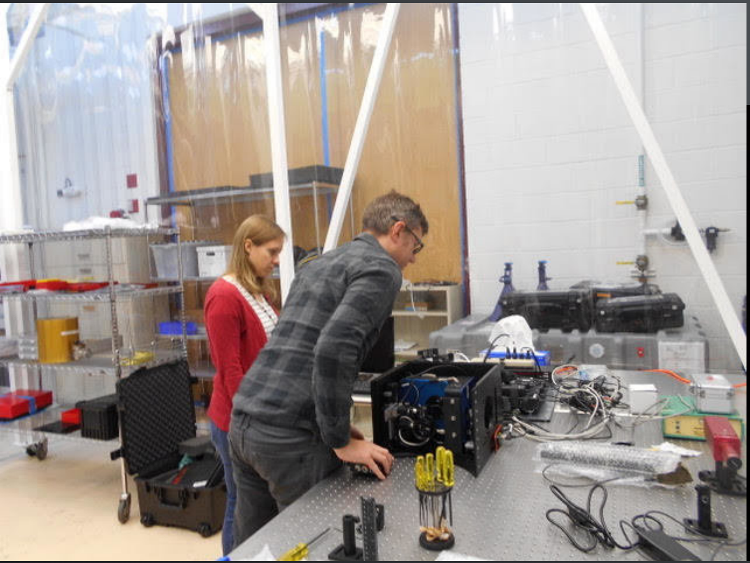


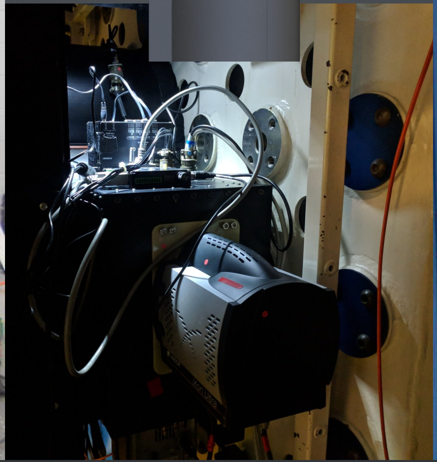
Dichroic
Dichroic
U
G
R
I
Z
g
r
i
z


ANDOR
ANDOR



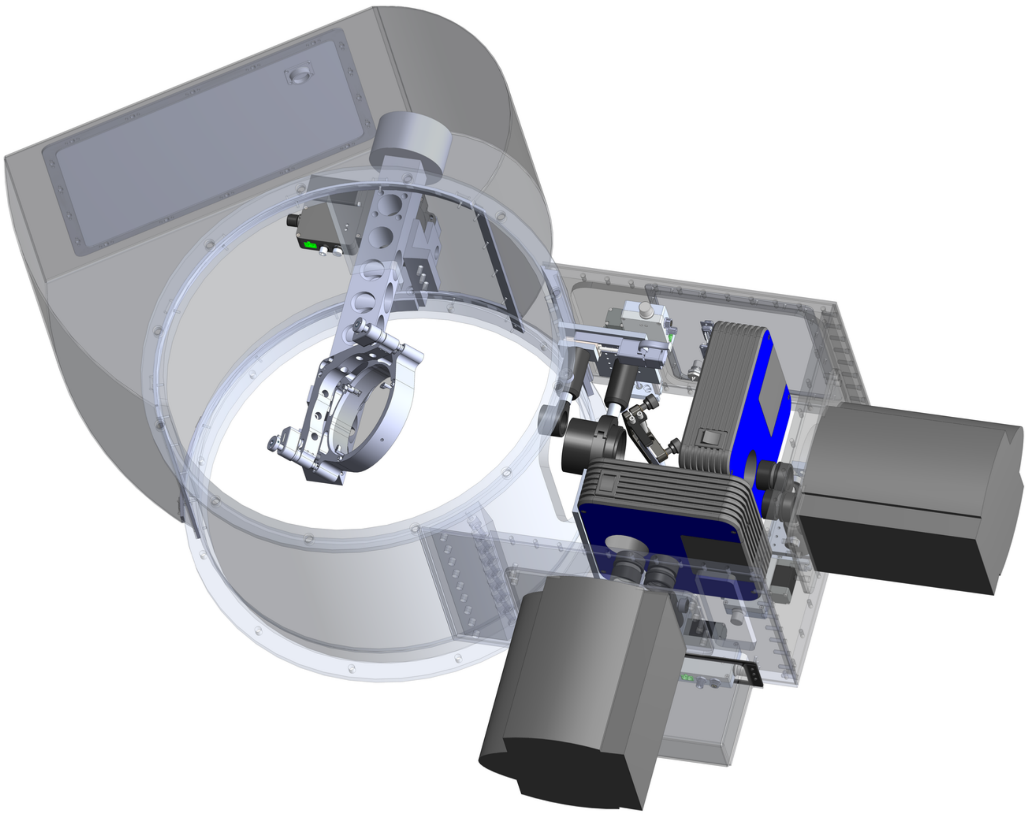






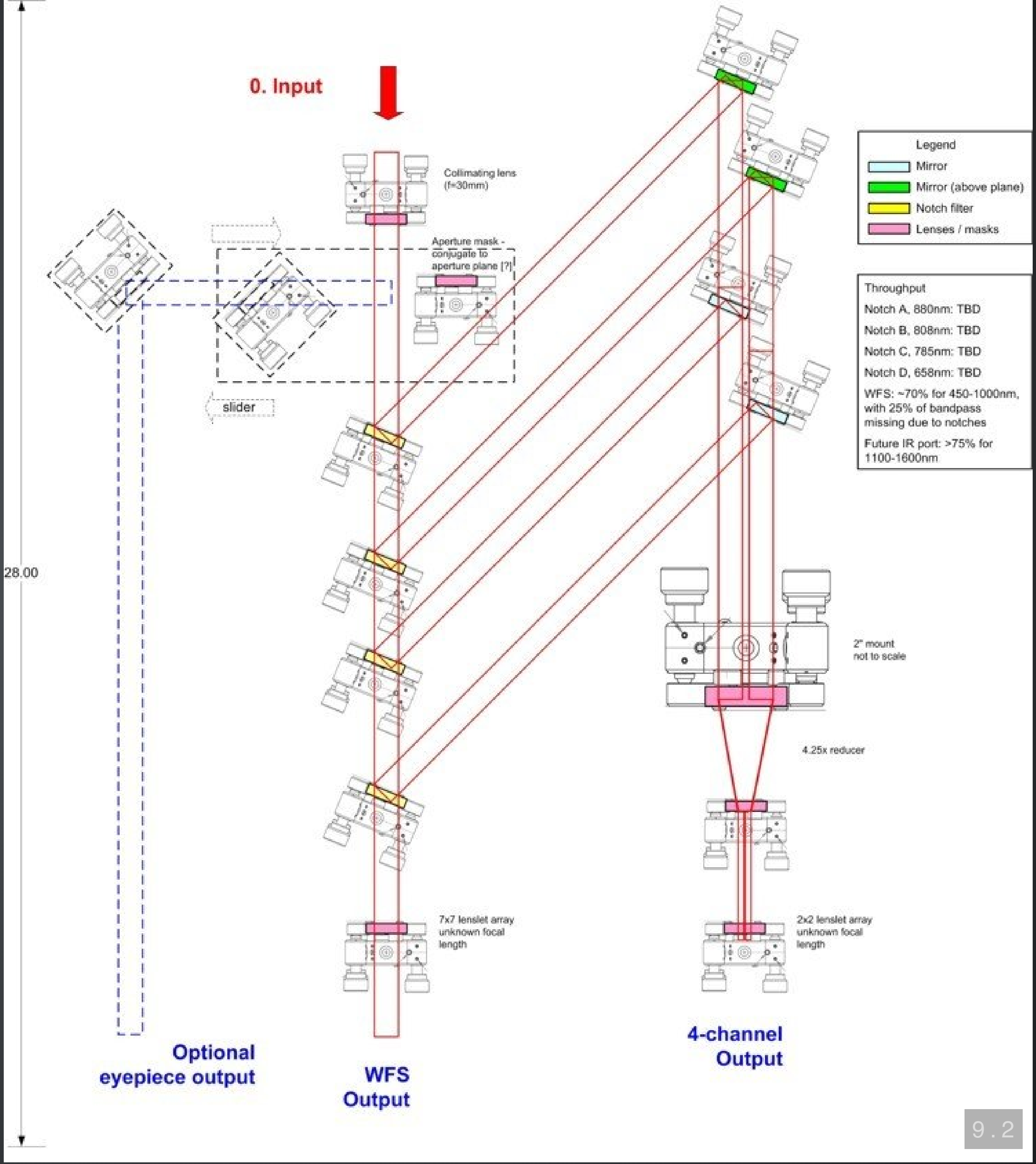
Twin instruments in the North and South.

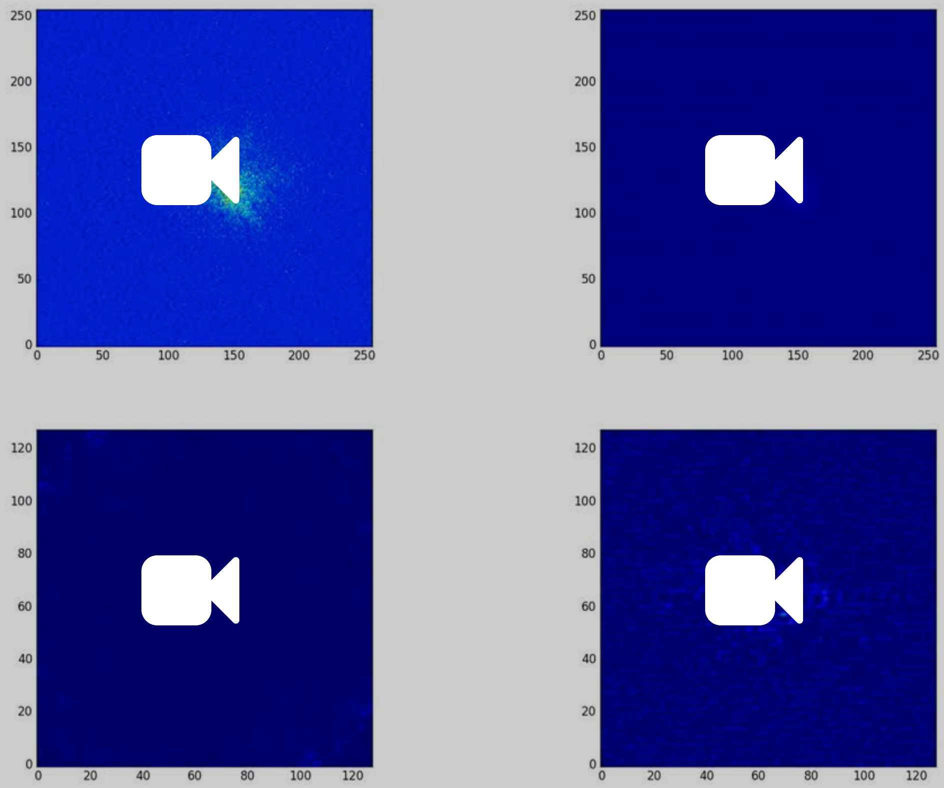
- TESS follow-up
- whole sky surveys

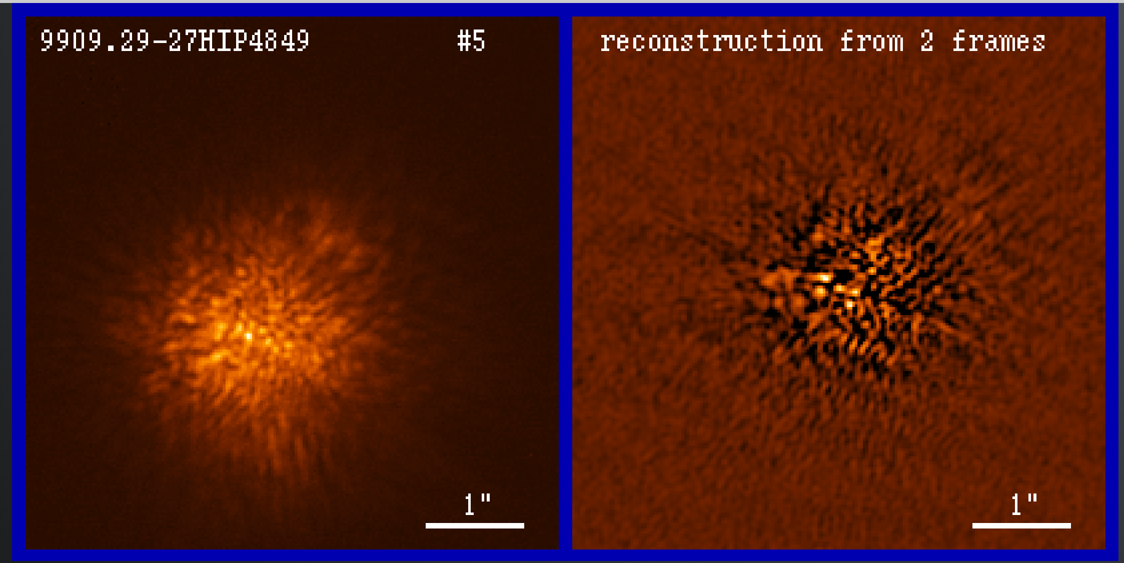


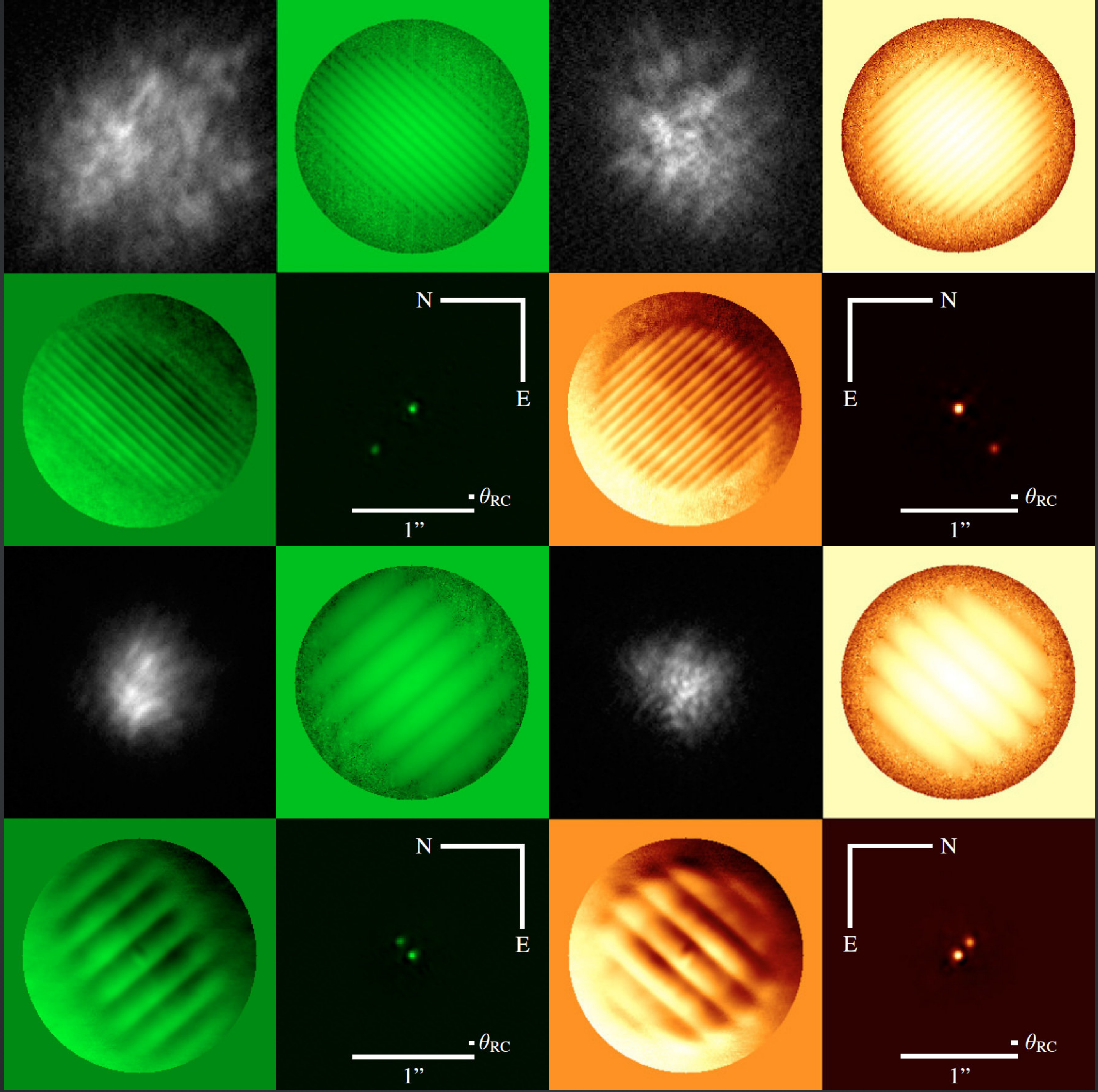
QWSSI

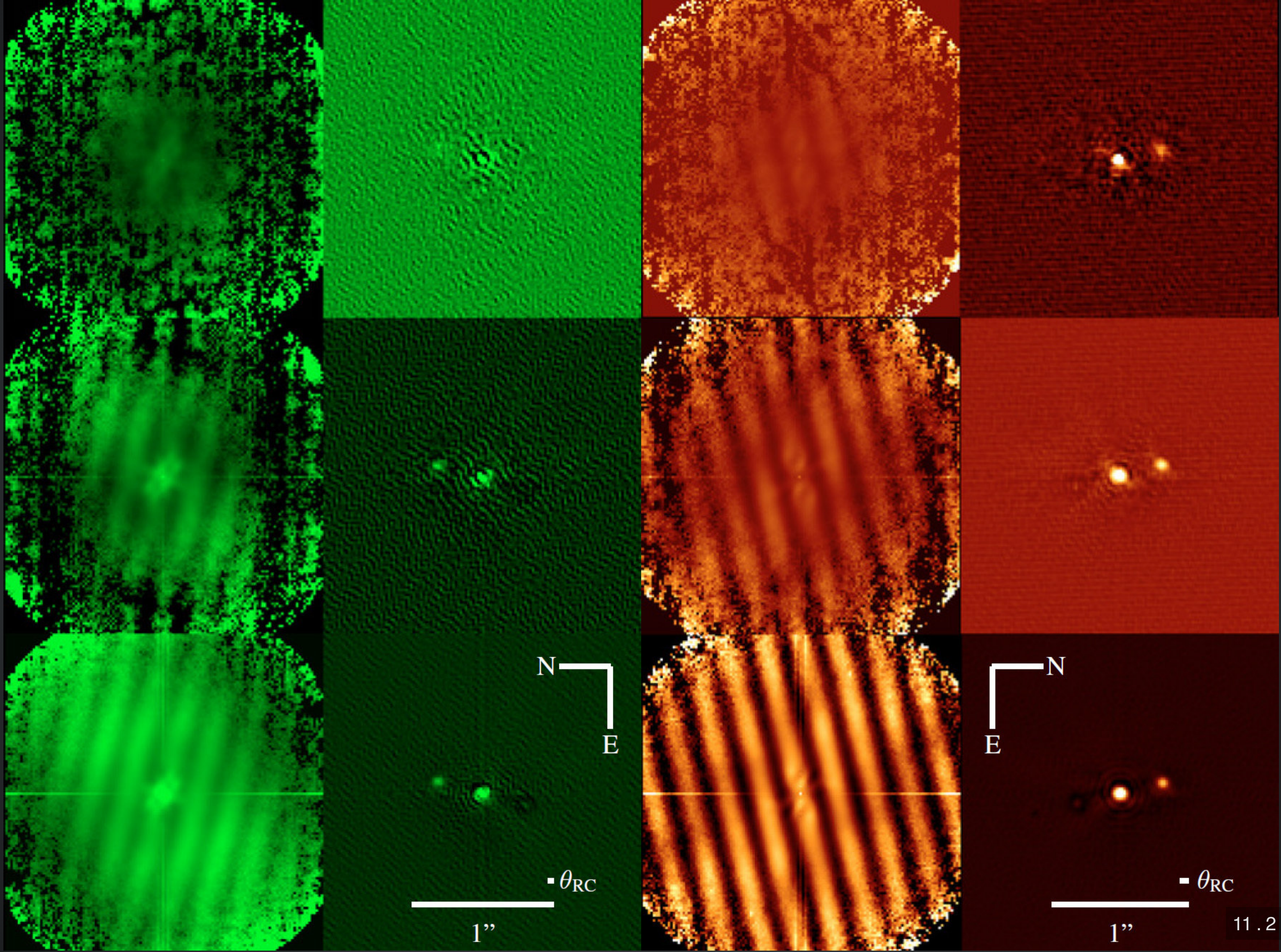
- Quad-channel
- Wave-front sensing
- Possible near-IR channel?
- DSSI heritage at the DCT+NPOI



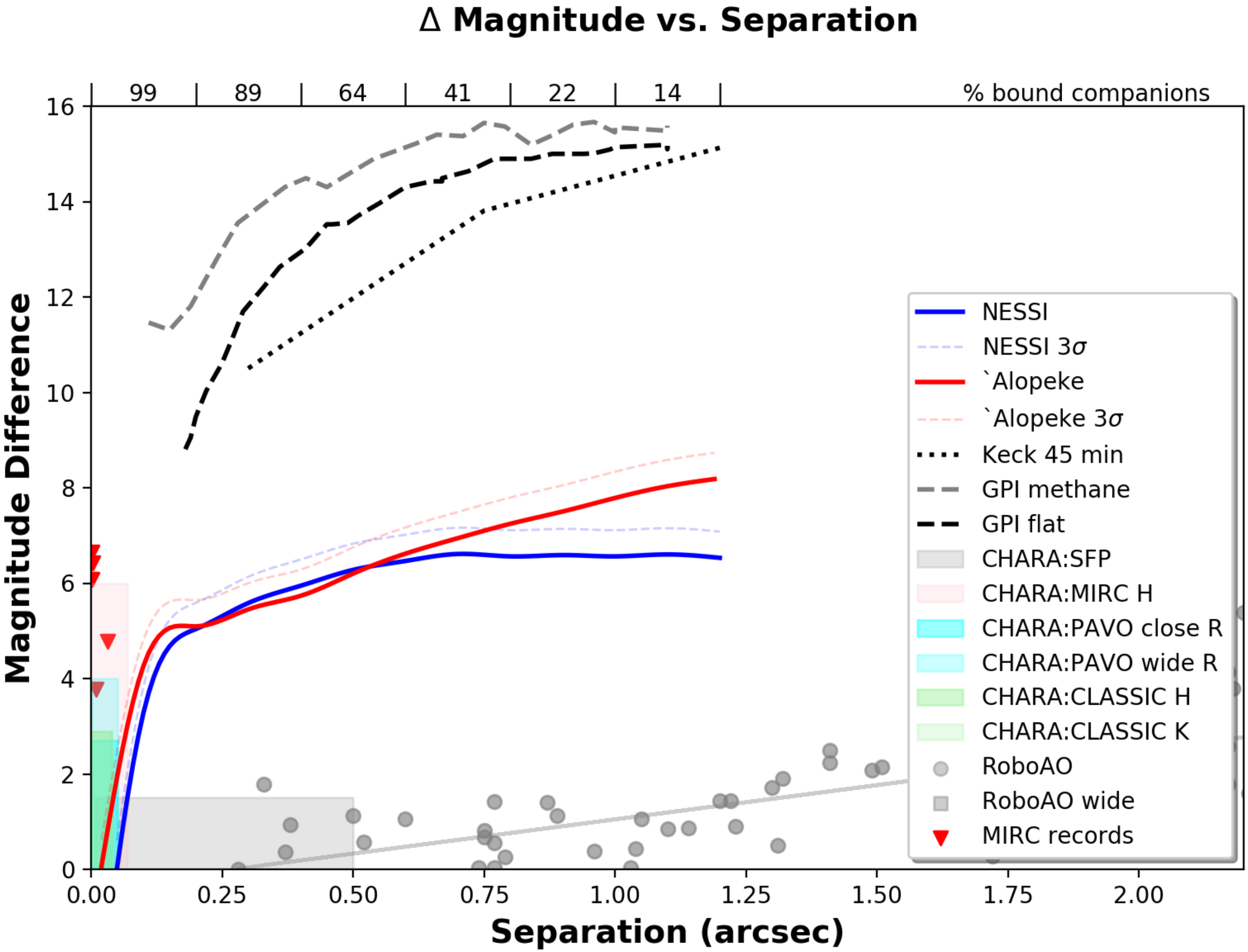

0 50 100 150 200 250
0 20 40 60 80 100 120


9909.29-27HIP4849
#5
1"
reconstruction from 2 frames
1"

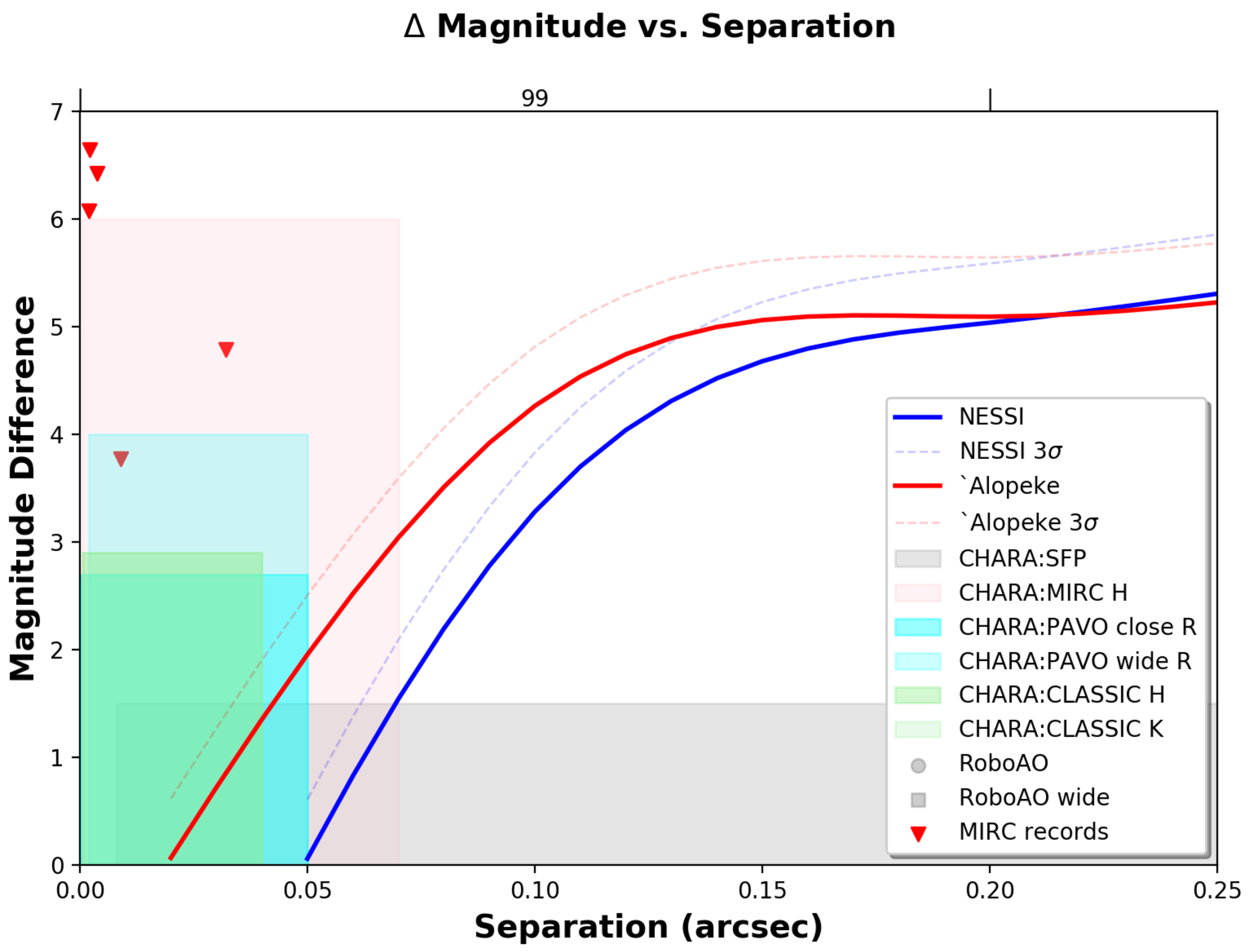

N
E
θRC
1"
N
E
θRC
1"
N
E
θRC
1"
N
E
θRC
1"



11.2



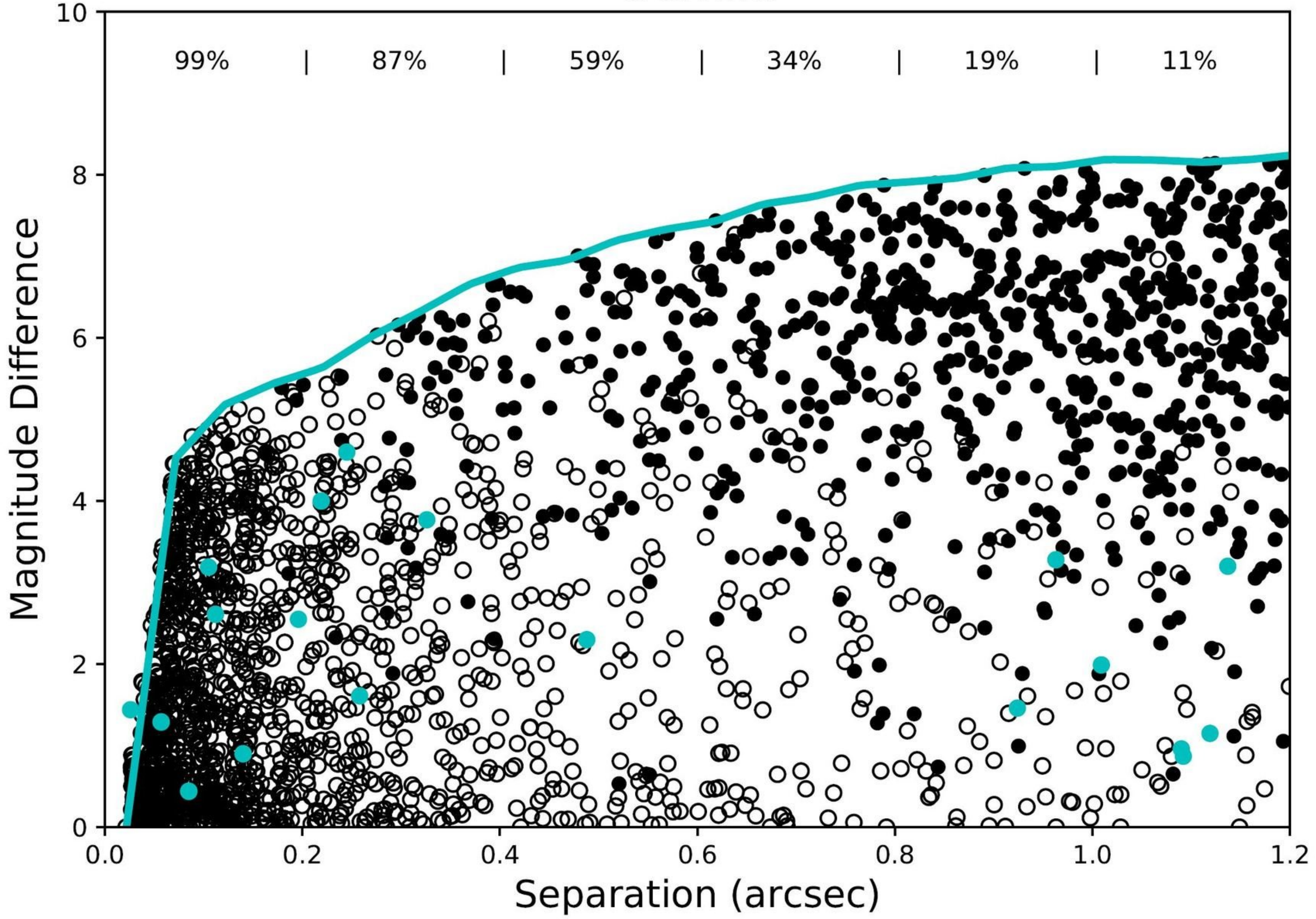
Δ Magnitude vs. Separation
99
89
64
41
22
14
% bound companions
Magnitude Difference
Separation (arcsec)
0
2
4
6
8
10
12
14
16
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
NESSI
NESSI 3σ
`Alopeke
`Alopeke 3σ
Keck 45 min
GPI methane
GPI flat
CHARA:SFP
CHARA:MIRC H
CHARA:PAVO close R
CHARA:PAVO wide R
CHARA:CLASSIC H
CHARA:CLASSIC K
RoboAO
RoboAO wide
MIRC records



Δ Magnitude vs. Separation
99
Magnitude Difference
Separation (arcsec)
0.00
0.05
0.10
0.15
0.20
0.25
0
1
2
3
4
5
6
7
NESSI
NESSI 3σ
`Alopeke
`Alopeke 3σ
CHARA:SFP
CHARA:MIRC H
CHARA:PAVO close R
CHARA:PAVO wide R
CHARA:CLASSIC H
CHARA:CLASSIC K
RoboAO
RoboAO wide
MIRC records

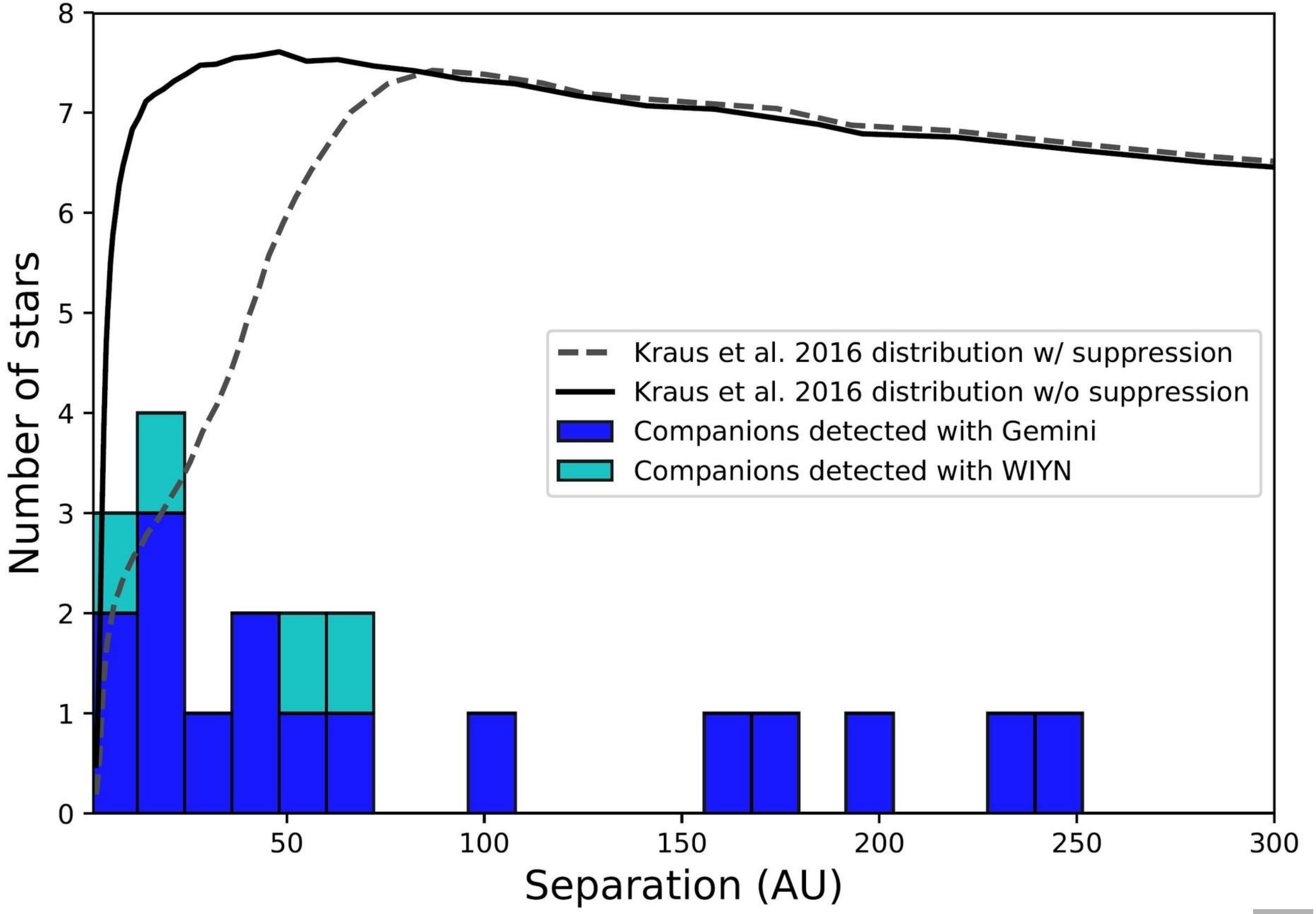
12.2

K2 binaries detectable with DSSI-Gemini

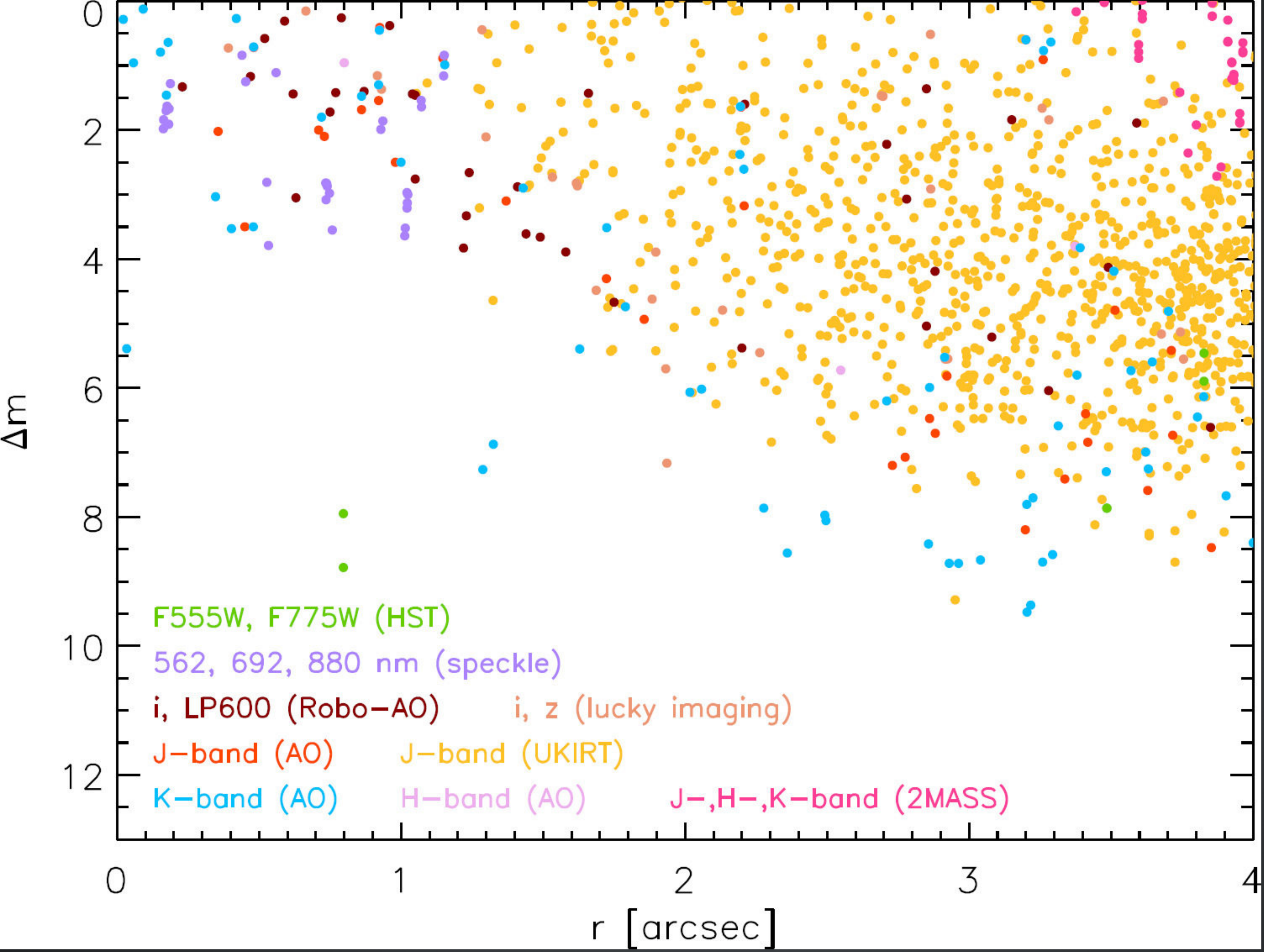


- observed
- bound (simulated)
- line-of-sight (simulated)

Matson et al. 2018 (submitted)

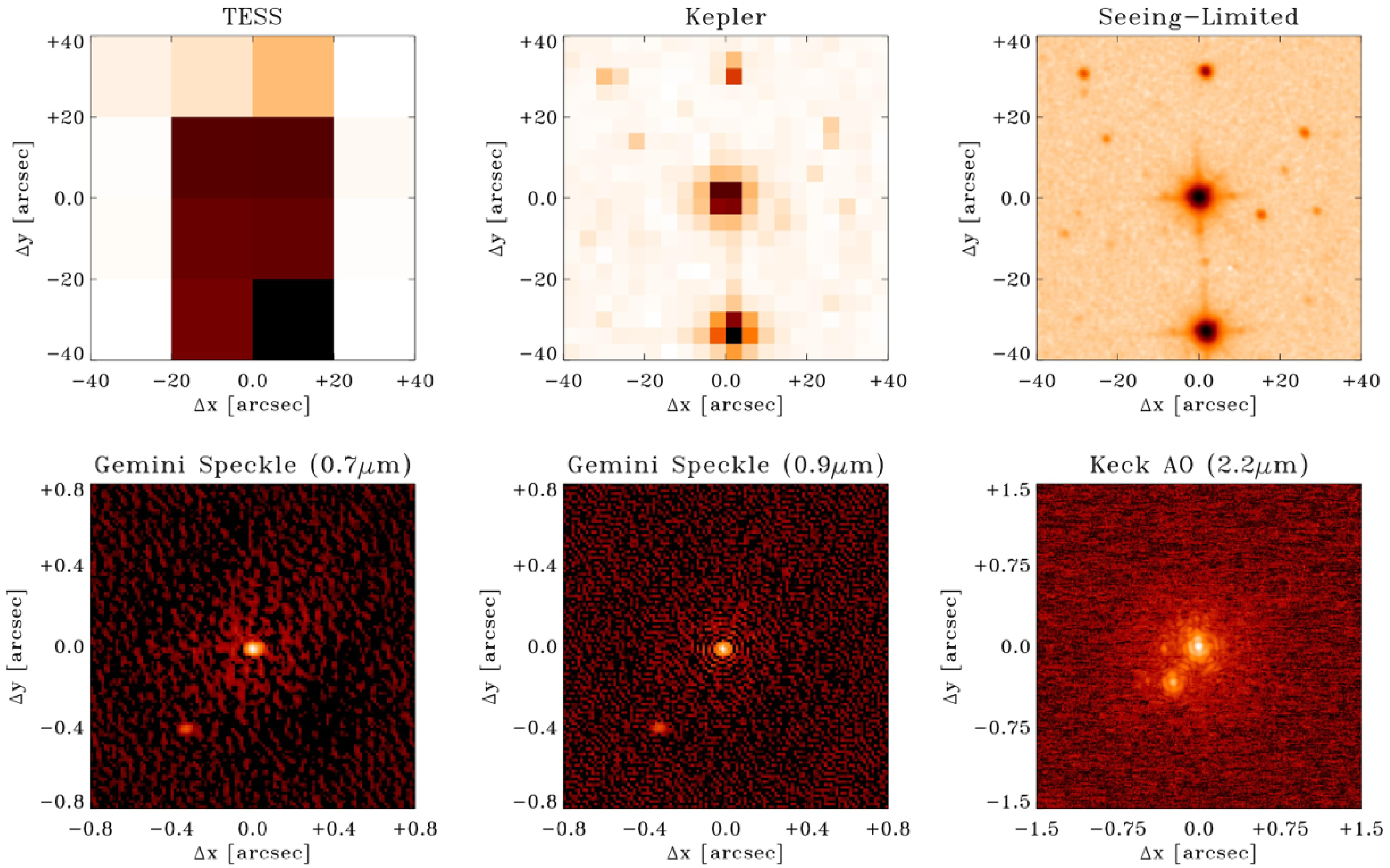


Number of stars
Separation (AU)
0
1
2
3
4
5
6
7
8
50
100
150
200
250
300
Kraus et al. 2016 distribution w/ suppression
Kraus et al. 2016 distribution w/o suppression
Companions detected with Gemini
Companions detected with WIYN

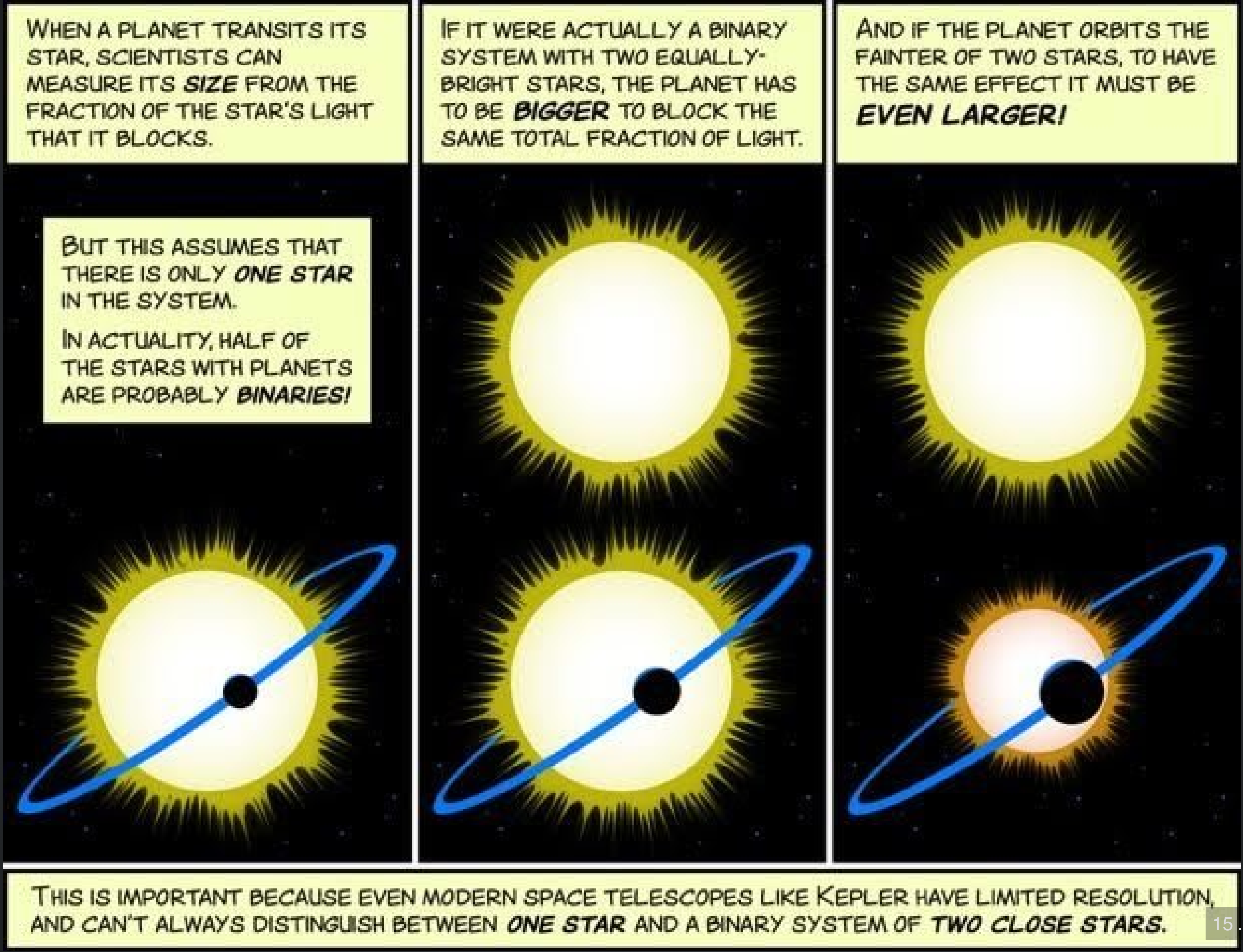


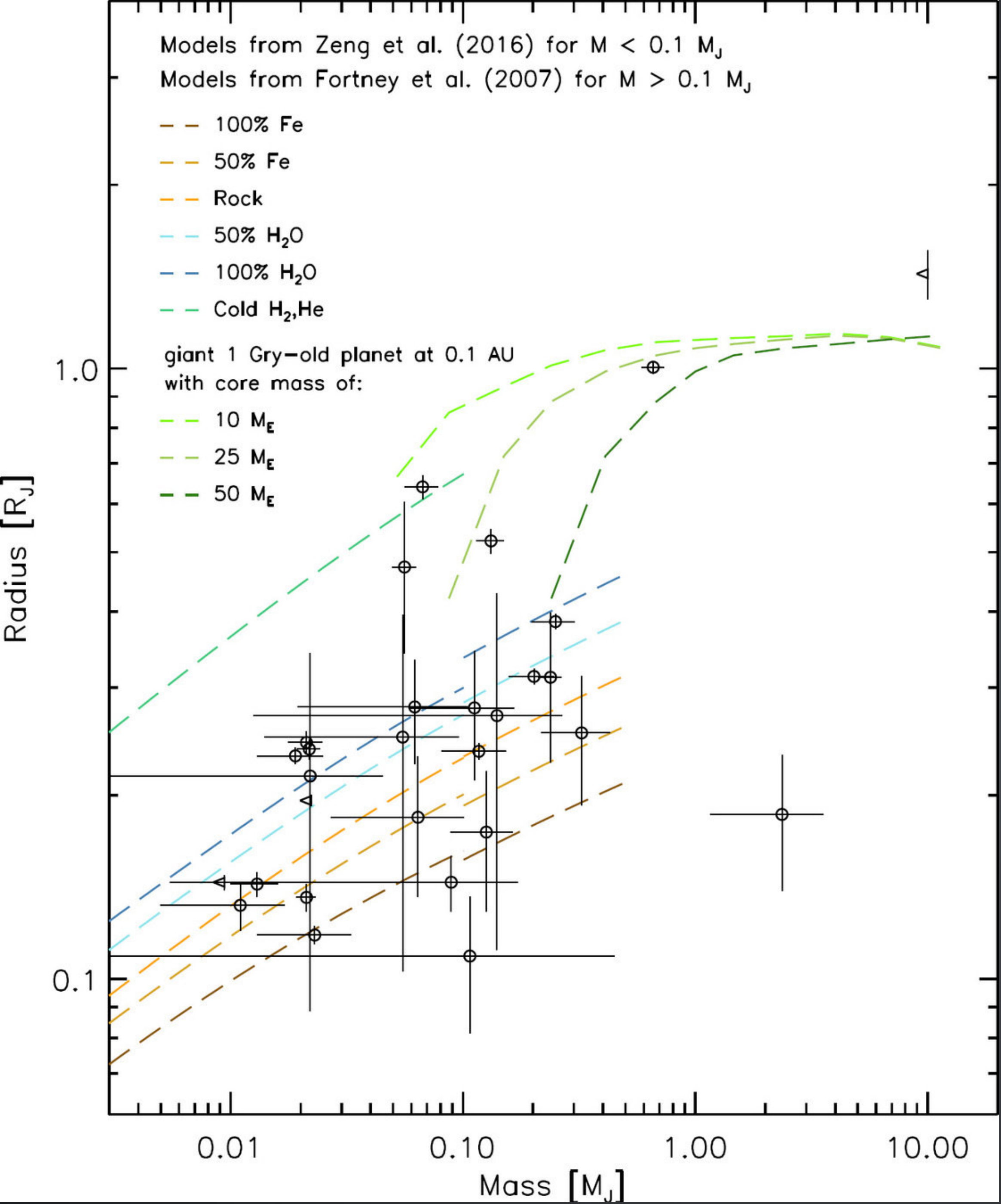
Companions of Kepler false positives

Furlan et al. 2017

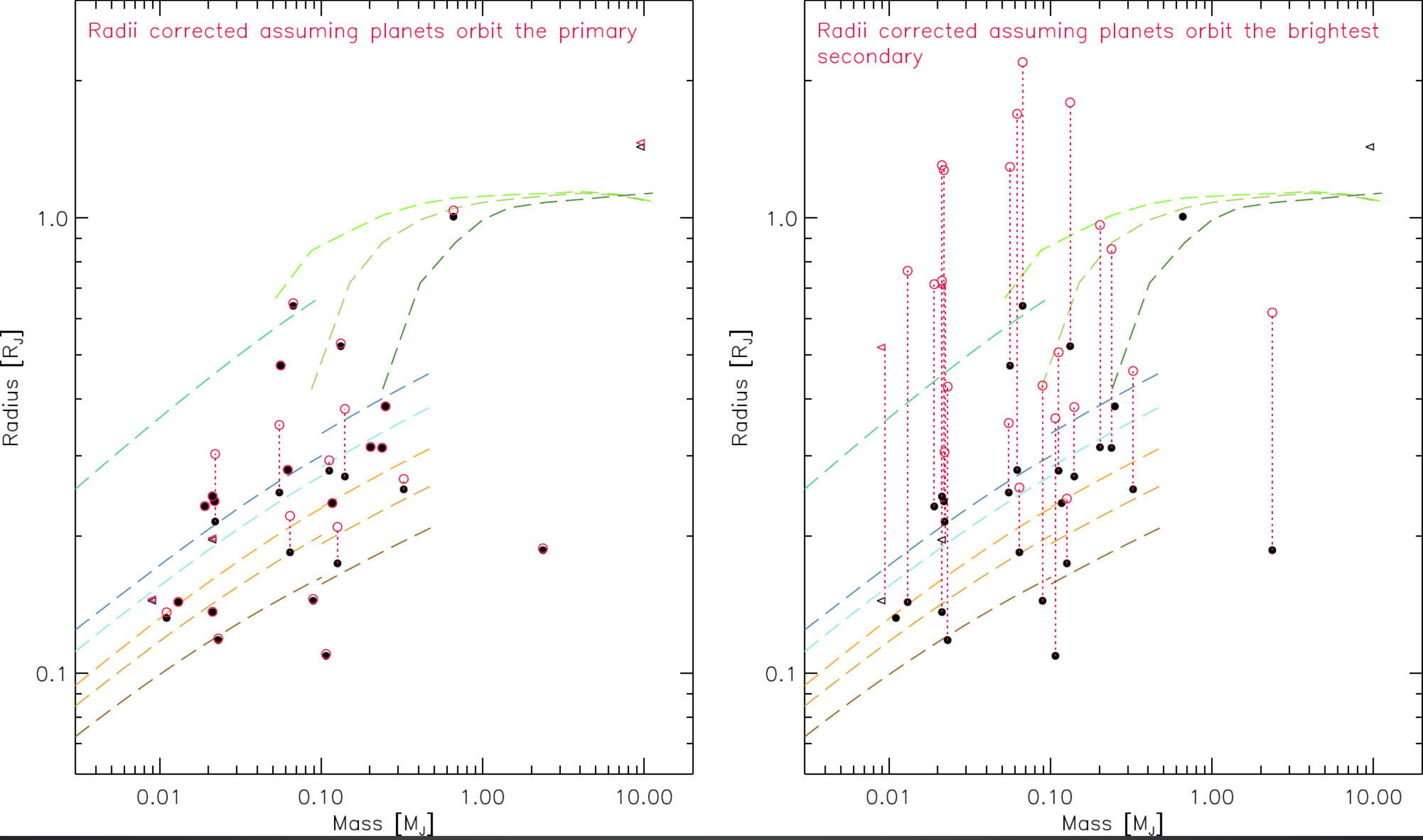


$$\frac{f_{\rm total} - f_{\rm transit}}{f_{\rm total}} = \delta_{\rm obs} = \left(\frac{f_{\rm transit}}{f_{\rm total}}\right)\left(\frac{R_{\rm planet}}{R_{{\rm transited}\star}}\right)^2$$


WHEN A PLANET TRANSITS ITS STAR, SCIENTISTS CAN MEASURE ITS SIZE FROM THE FRACTION OF THE STAR'S LIGHT THAT IT BLOCKS.
BUT THIS ASSUMES THAT THERE IS ONLY ONE STAR IN THE SYSTEM.
IN ACTUALITY, HALF OF THE STARS WITH PLANETS ARE PROBABLY BINARIES!
IF IT WERE ACTUALLY A BINARY SYSTEM WITH TWO EQUALLY-BRIGHT STARS, THE PLANET HAS TO BE BIGGER TO BLOCK THE SAME TOTAL FRACTION OF LIGHT.
AND IF THE PLANET ORBITS THE FAINTER OF TWO STARS, TO HAVE THE SAME EFFECT IT MUST BE EVEN LARGER!
THIS IS IMPORTANT BECAUSE EVEN MODERN SPACE TELESCOPES LIKE KEPLER HAVE LIMITED RESOLUTION, AND CAN'T ALWAYS DISTINGUISH BETWEEN ONE STAR AND A BINARY SYSTEM OF TWO CLOSE STARS.



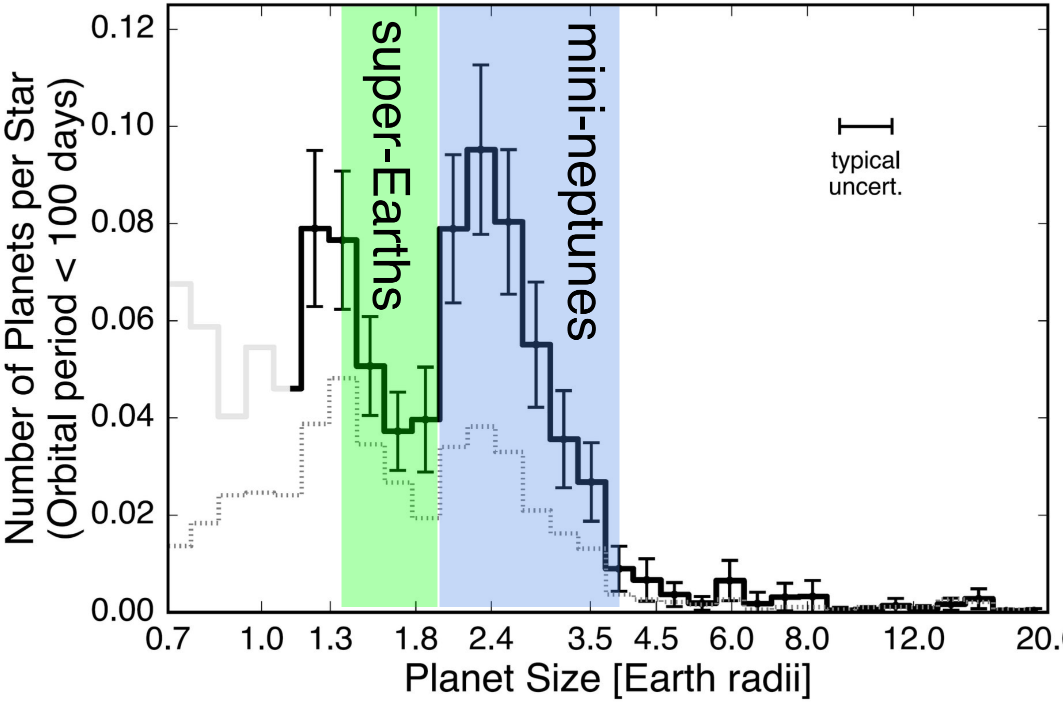
Furlan & Howell 2017

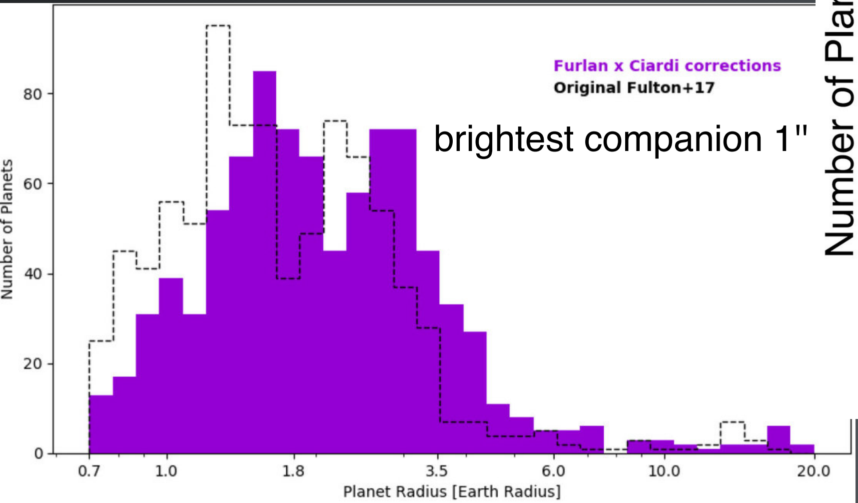


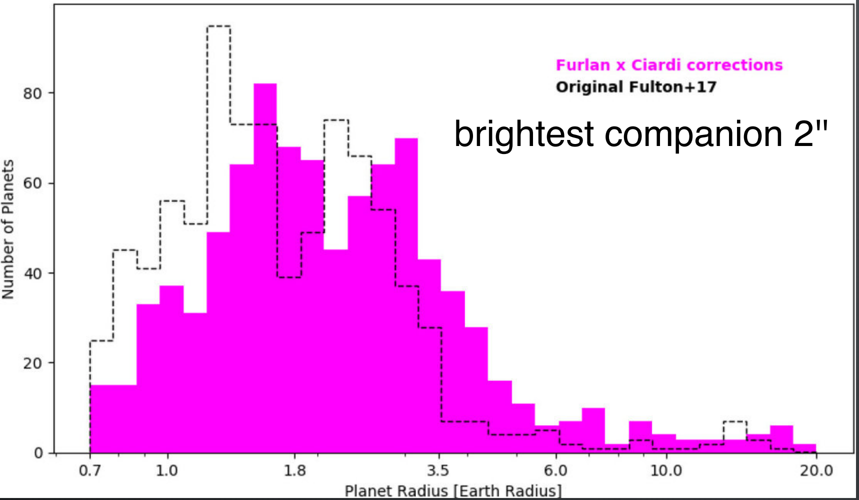
Furlan & Howell 2017

Shift from 1.8 to 2.2 R_E implies increased water/ice content vs pure Si rock

Fulton

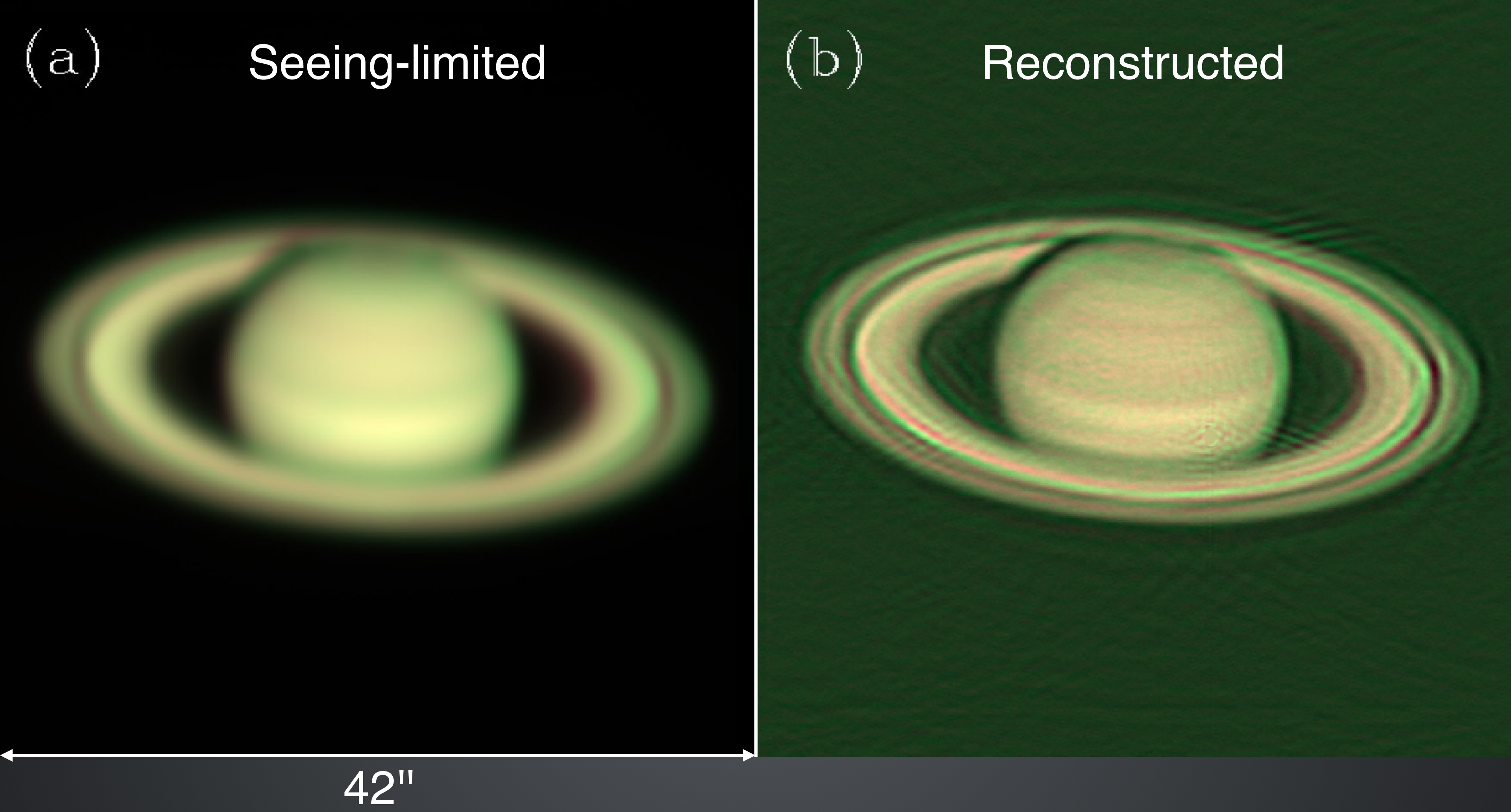






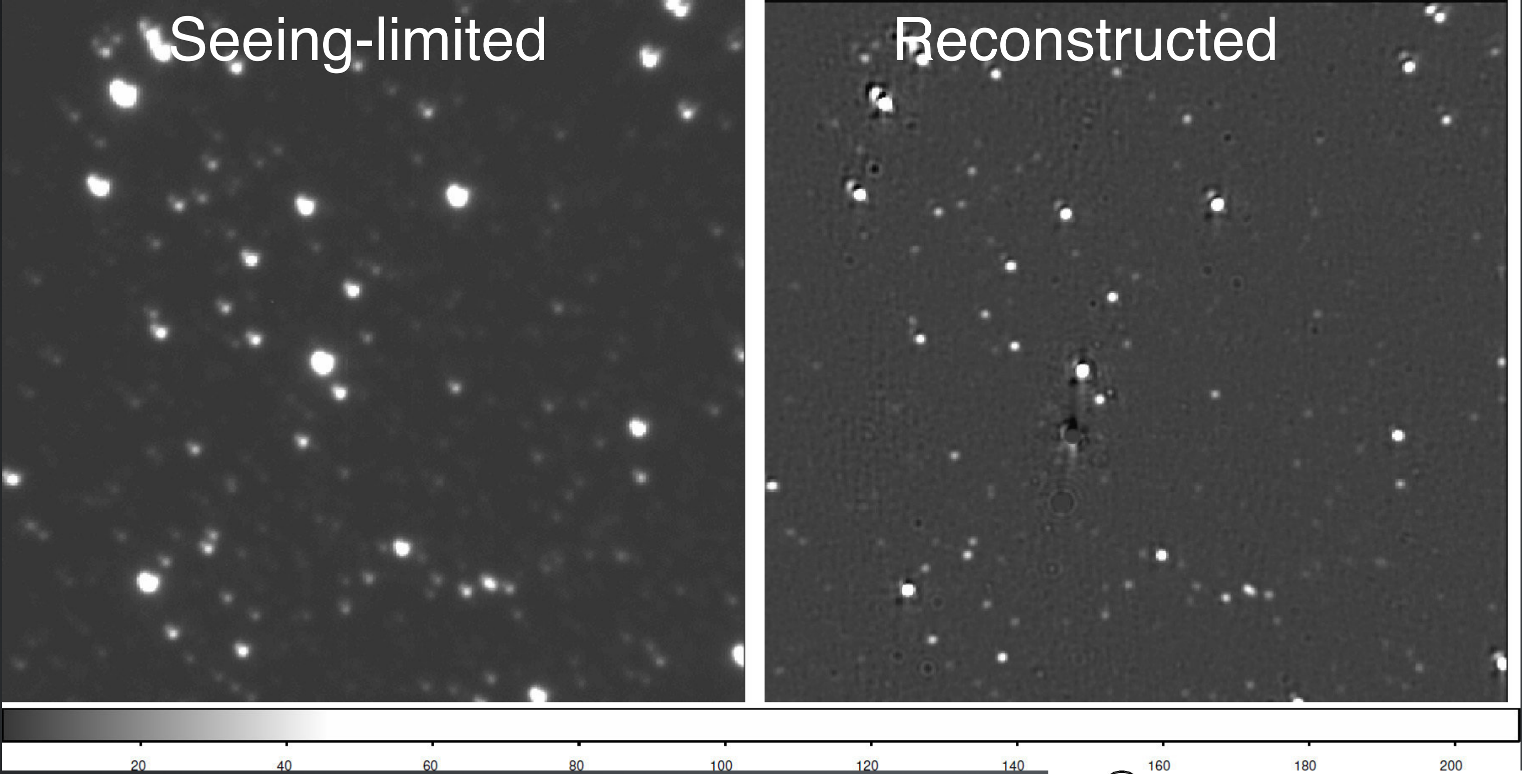
- Large radius errors originally hid distribution features
- Fulton gap revealed after CKS (10% stellar radius errors)
- Accounting for binarity shifts gap in the distribution

Teske et al. (in prep.)



Two-color wide-field speckle reconstruction

- 0.25'' resolution from 500 frames (20s)
- compromise b/t angres and contrast
- Seeing ~ 0.85''



M13

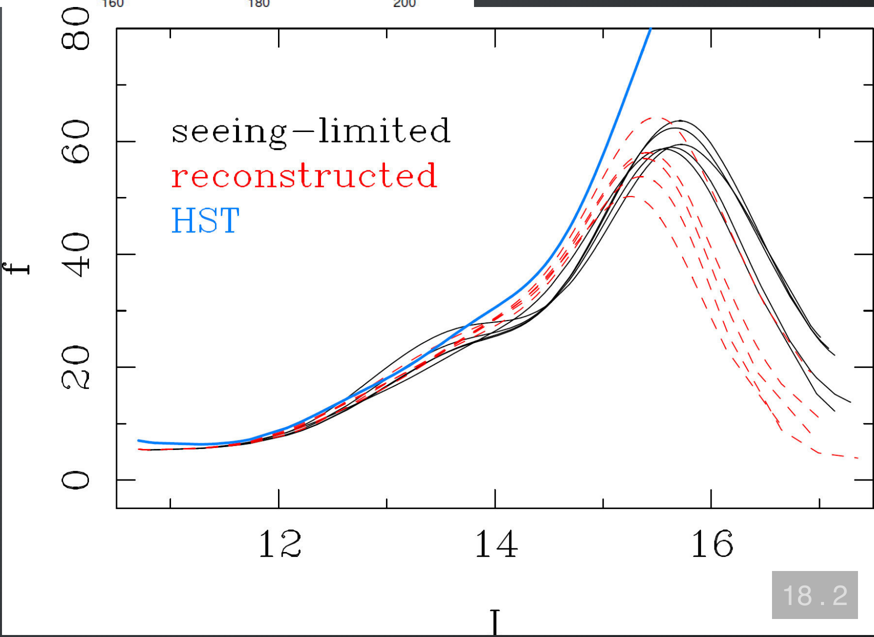
- astrometry of clusters
- very early results and little calibration or modelling over the FoV

Abs astrometry residuals
~6-7 mas   4.2 mas

Further improvement possible to obtain ~0.02 pix (~0.4mas)

- optics, dither, deeper obs

0.05 mag accuracy on aperture photometry



NEAs

- sizes
  - radar typically quotes 40% uncertainties
  - albedo/radar size mismatch
- shapes
  - adapt stellar surface modeling tools
  - light curve inversion/illumination model

Asteroid Kleopatra imaged at Gemini. The images are 2.8 x 2.8 arcsec and show 550 nm (left) and 880nm (right)

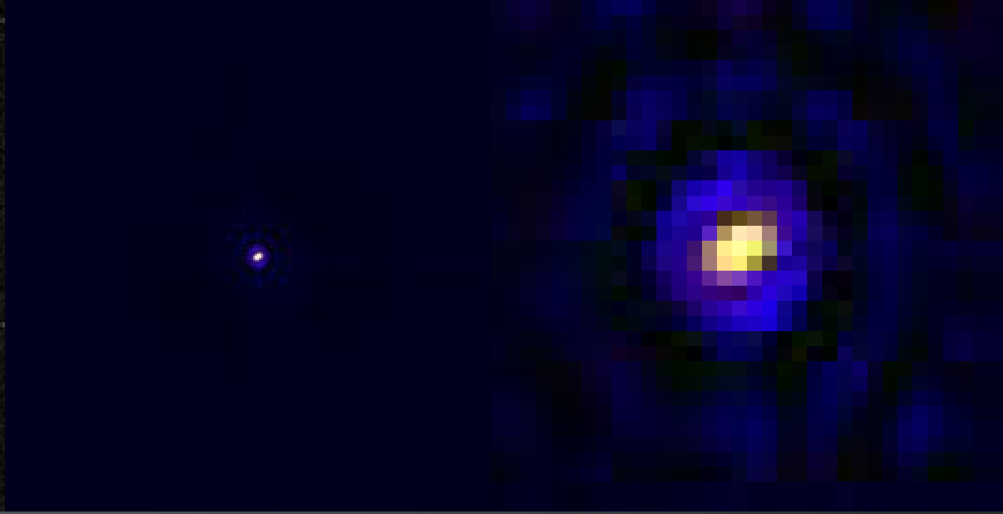
H310008 = 216 Kleopatra

a~2.8AU

d~270km x 80km

(neck~50-65km)

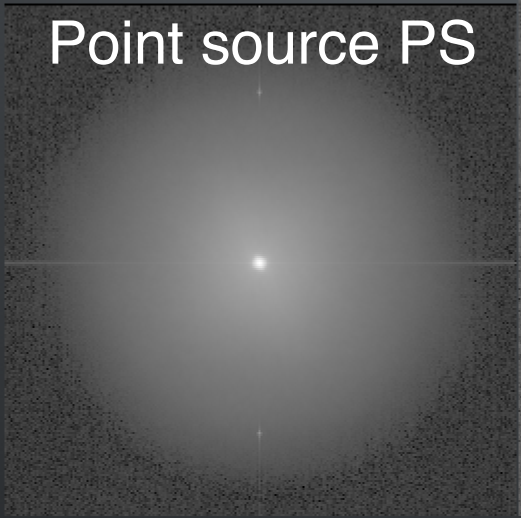
model: Franck Marchis



Phaethon

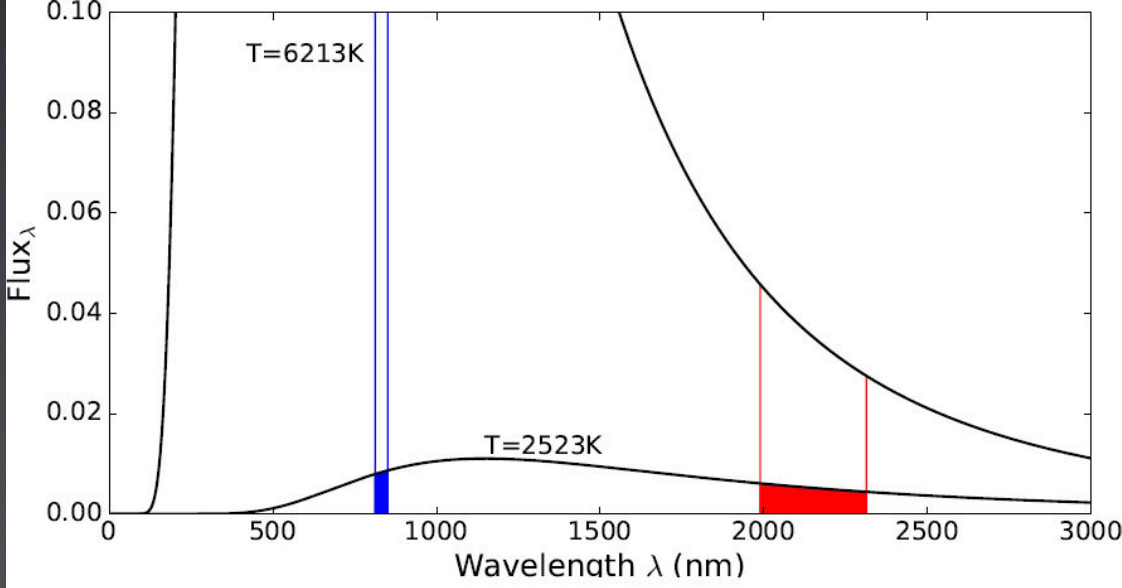
Dec 2017 ~ 0.07AU

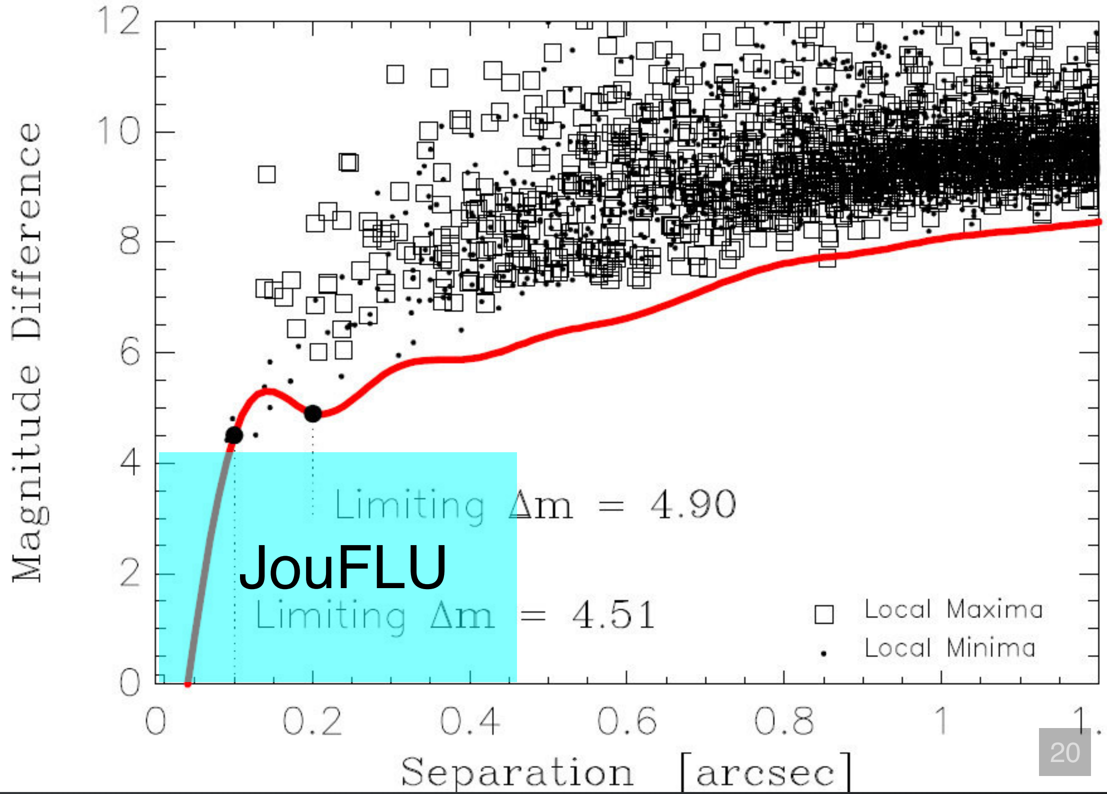
d~6km



Exozodis

- Flux limited to 1.6% at 0.1"
- Any companion T ≥ 2500K (M8V/M9V) is eliminated.





Open to the community

- NOAO proposal process
- NESSI - WIYN@KPNO
- `Alopeke - Gemini-N
- DSSI - Gemini-S
- Transitioning from block queue operation to Facility Instrument status

NPP & internship opportunities: see me for details

Some other proposals so far:

- Constrain NEA diameters. Image SS objects.
- Determine multiplicity of nearby K and M-dwarfs, does it vary across spectral type?
- Imaging of brown dwarfs and distant large planets, particularly around M dwarfs.
- Investigate differences in planetary system architectures between multiple vs not (known) multiple host stars.
- Examine long term RV trends/determine binarity of RV planet hosts.
- K2, TESS follow-up
- Provide and unbiased sample for TESS, so statistical determinations of planet occurrence rates can be made.
- Occultations, Transit photometry, Pulsar time scales, observe pulsating WDs at high cadence....

References

- Scott, Howell, Horch, & Everett. PASP 2018 (accepted)
- Horch et al. AJ 2012
- Furlan et al. AJ 2017
- Furlan & Howell AJ 2017
- Horch & Casetti-Dinescu 2018 (in prep.)
- Matson et al. 2018 (submitted)
- Teske et al. 2018 (in prep.)
- Fulton et al. AJ 2017