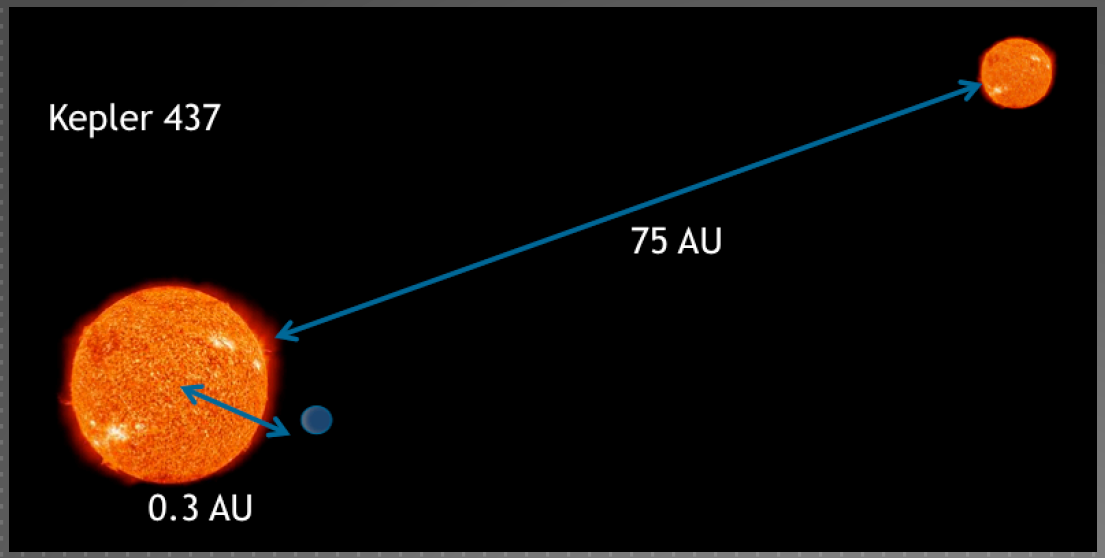
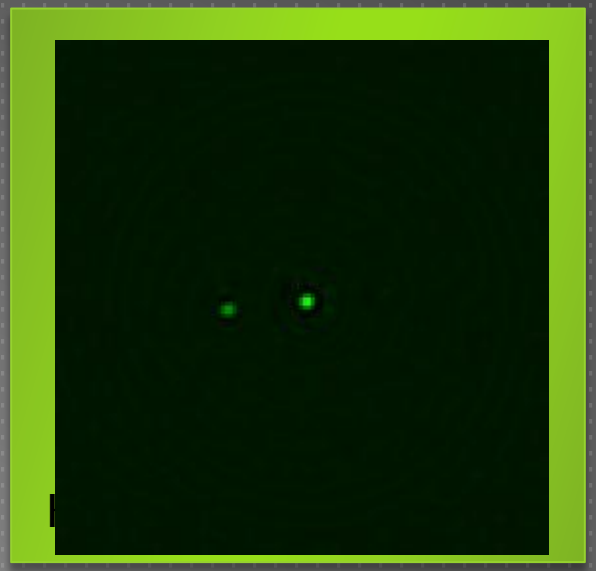
STELLAR MULTIPLICITY AND ITS ROLE IN EXOPLANETARY SYSTEMS





Elliott Horch, SCSU

SOME POSSIBLE EFFECTS OF A SECOND STAR

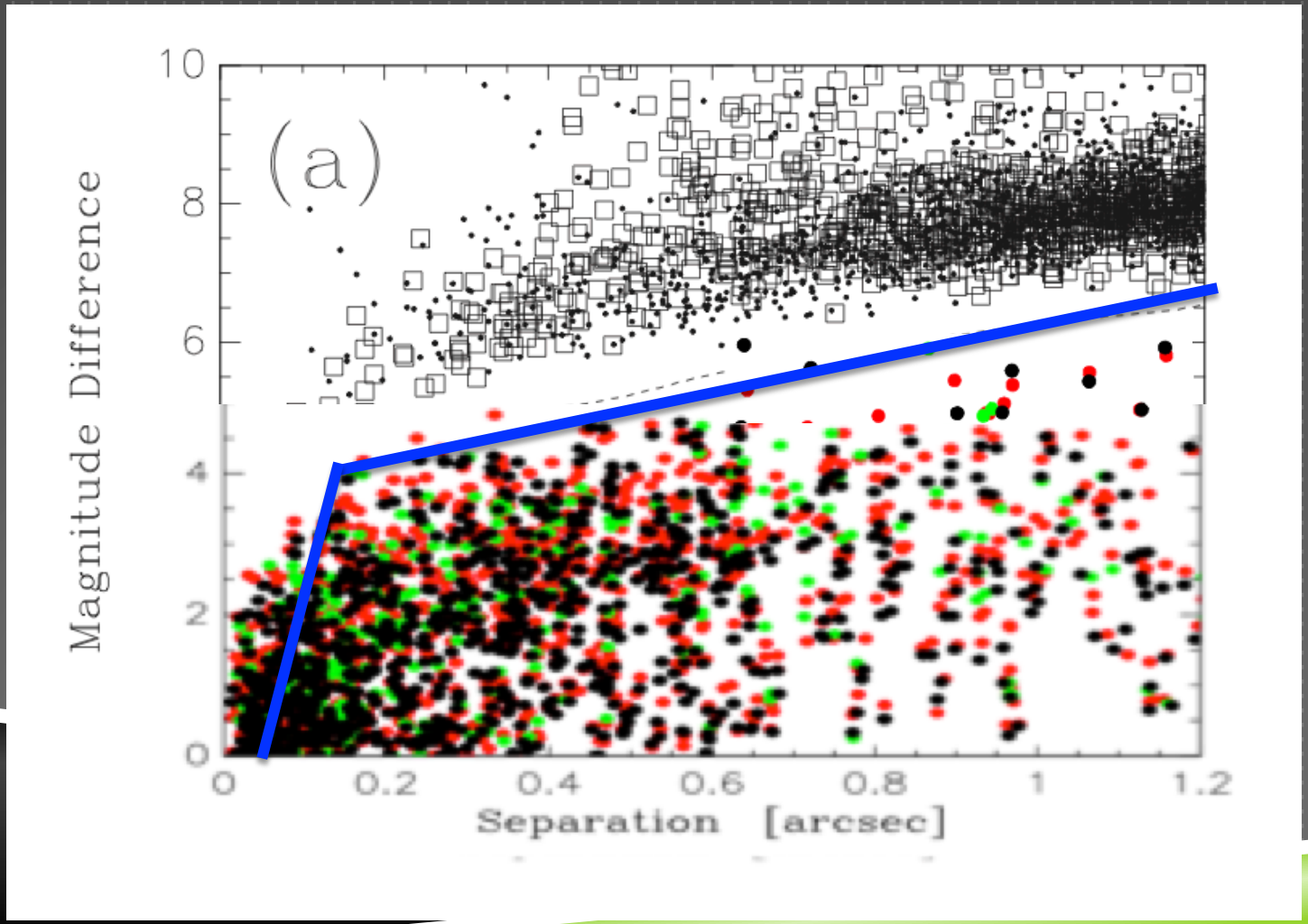
- Formation: a Second Star could Affect the Disk Properties
  - Truncation
  - Circumbinary disk
  - Disruption
- Orbital Dynamics and Stability
  - Orbital parameter statistics
  - Orbital Alignments or Misalignments
  - Migration
- Detection/Characterization of Exoplanet Systems and Statistics
  - Dilution of transit signal
  - Other observational biases: binaries as a "complicating factor" in many studies.

Main Tools:
Radial Velocity (RV) measurements and
High-Resolution Imaging (HRI)

WHAT HRI DOES FOR YOU

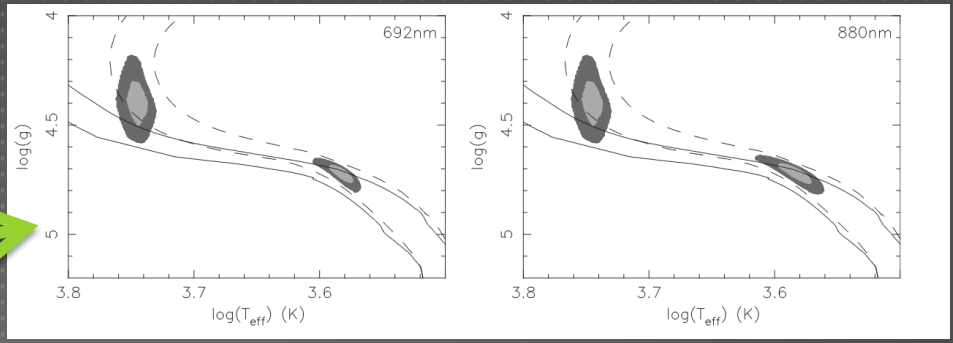
Images from the DSSI speckle camera.

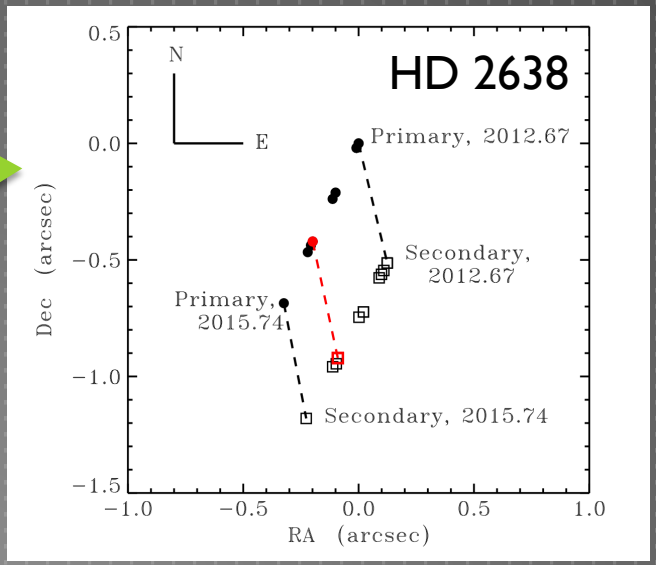
SPECKLE DETECTION LIMITS (WIYN)



TESTS OF PHYSICAL ASSOCIATION

- Statistical arguments based on observed parameters.
- H-R Diagram Placement
  - Everett et al. (2015)
  - Morton (about half an hour from now)
- Common Proper Motion
  - Wittrock et al. 2016
- Orbit Determinations
  - (more on that later this session too)



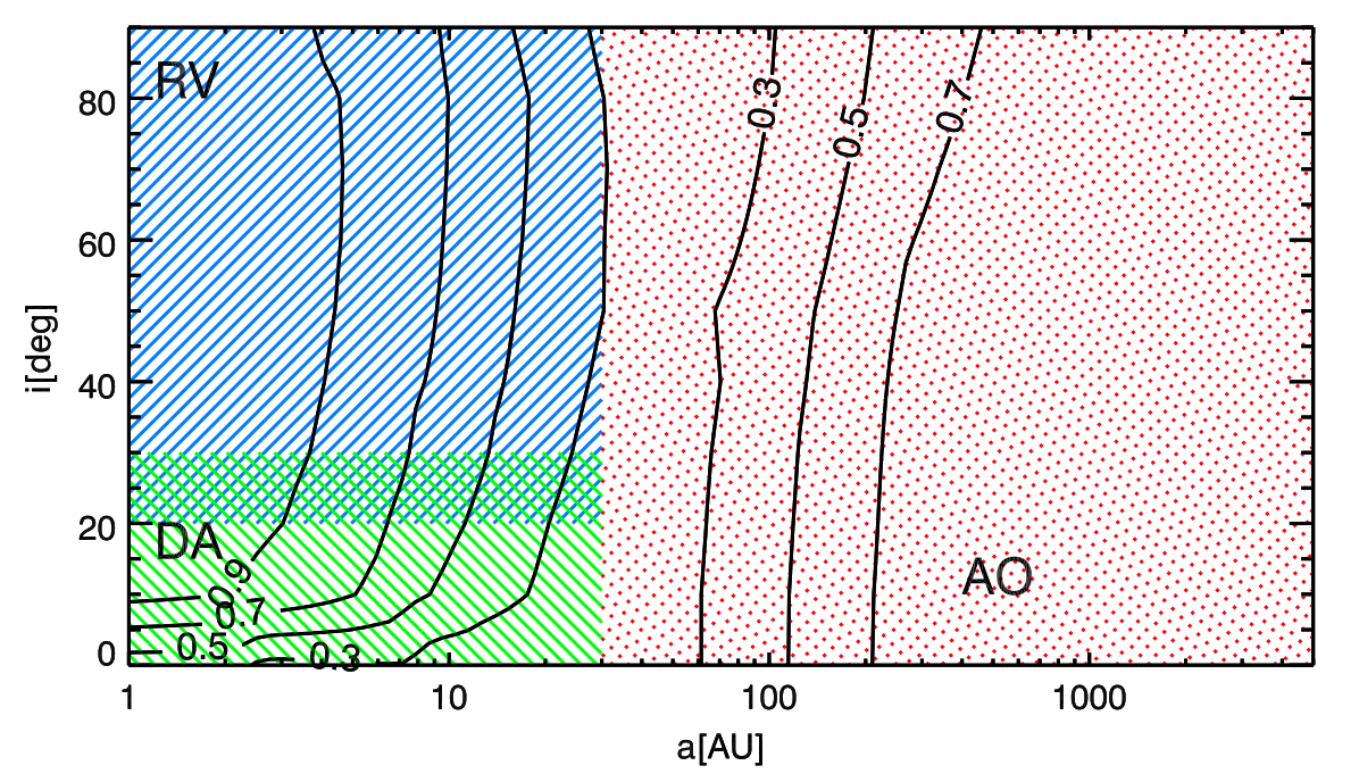


KEPLER AND COMPANIONS

- Several studies have attempted to assess the multiplicity rate for systems with exoplanets.
- Planet searches in binaries, e.g.:
  - **Konacki et al. (2009):** Search for P-type planets around SB2s.
- Searches for companion stars near known exoplanet hosts, e.g.:
  - **Wang et al. (2014, 2015):** RV and AO data suggest suppression of stellar companions within 100AU of stars hosting Jupiters.
  - **Furlan et al (2017):** ~30% of KOIs have at least 1 stellar companion within 4".
  - **Horch et al. (2014)** Speckle imaging of KOIs at WIYN & Gemini reveals no statistically significant difference from DM/Raghavan. Most sub-arcsec components are bound. See also Teske et al (2015), Hirsch et al (2017).

Caveat:
Incompleteness and observational biases are difficult to overcome.

KEPLER AND COMPANIONS

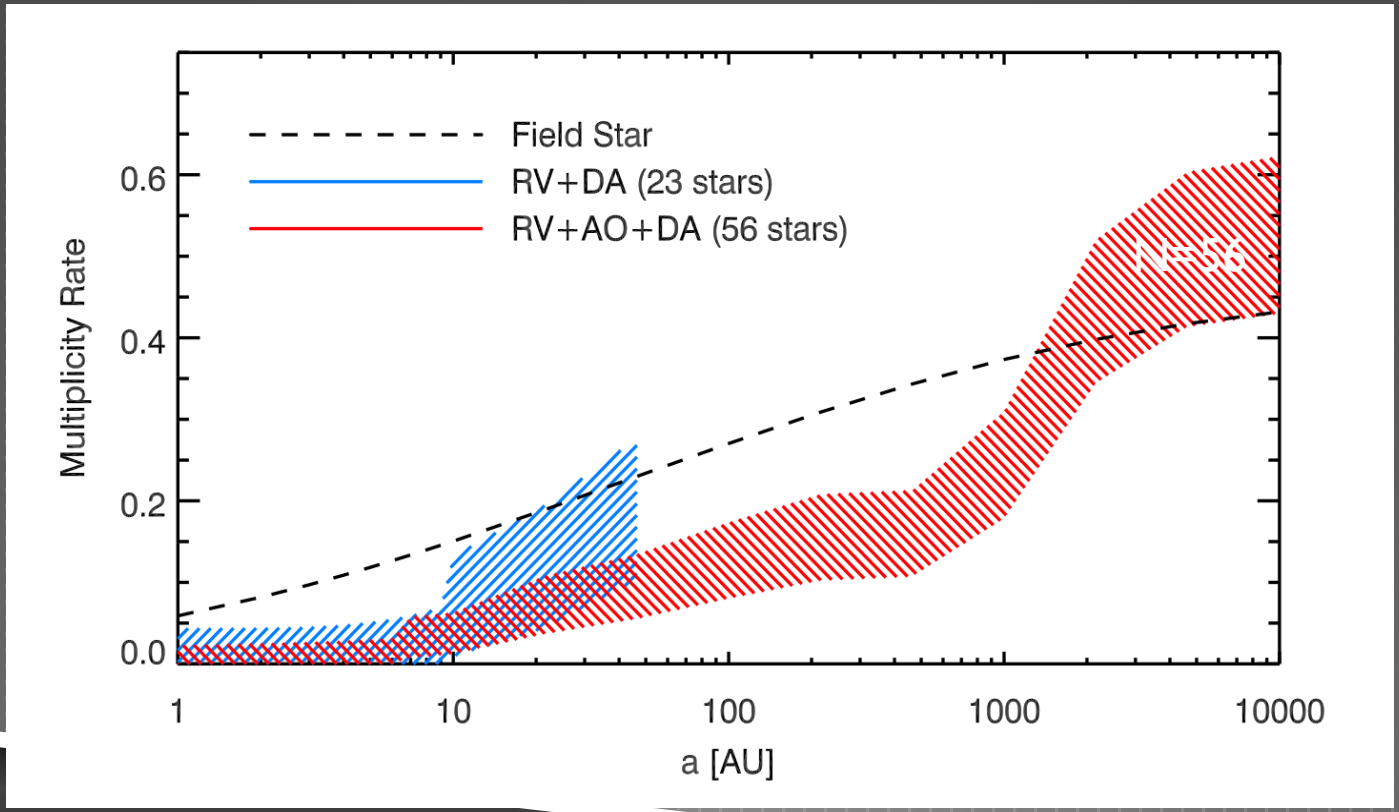


Wang et al (2015)

A trough in detection efficiency occurs near the peak of the DM distribution.

RV AND AO DATA

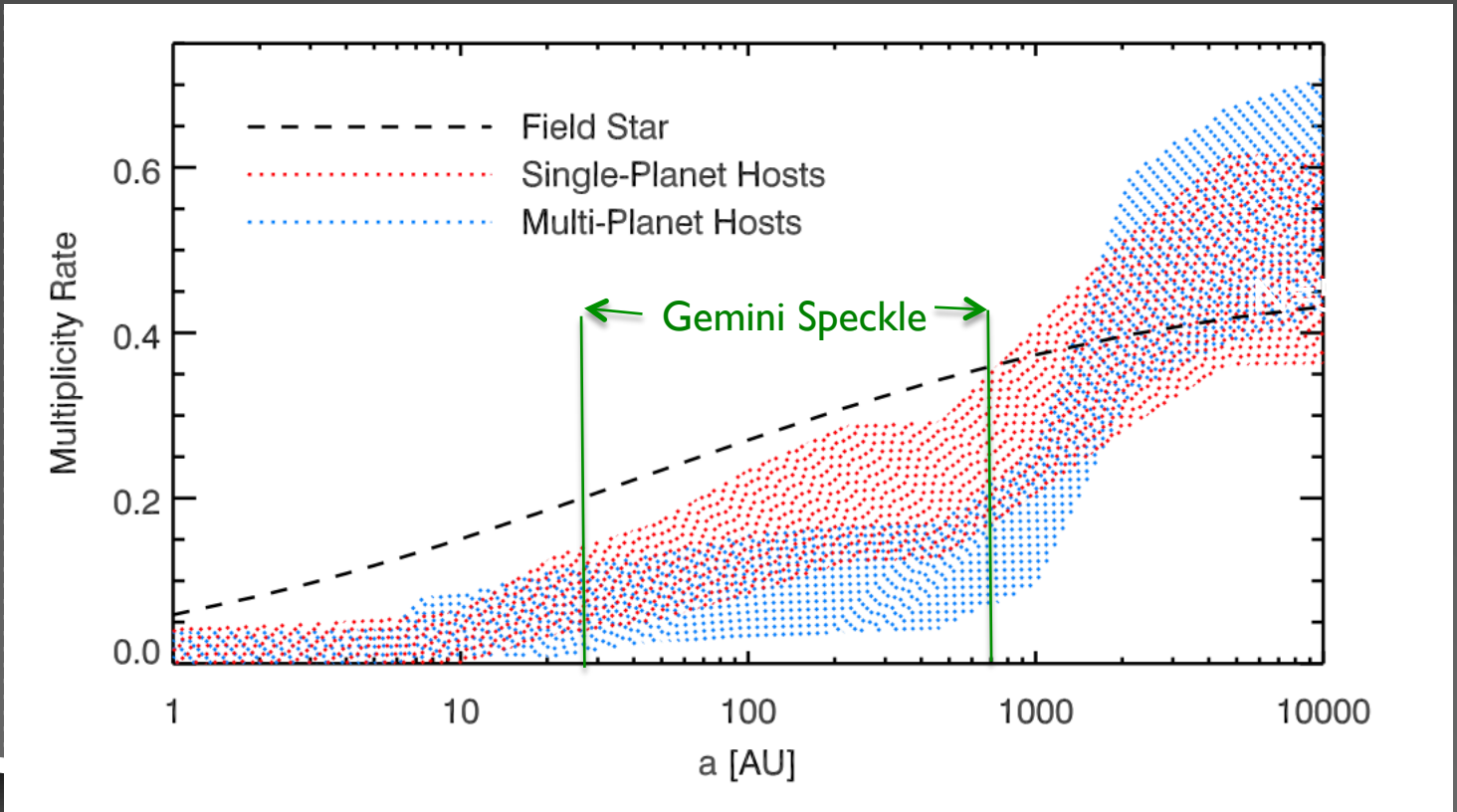
Wang et al (2014)



Truncated Disk: Second star disrupts the outer part of disk.

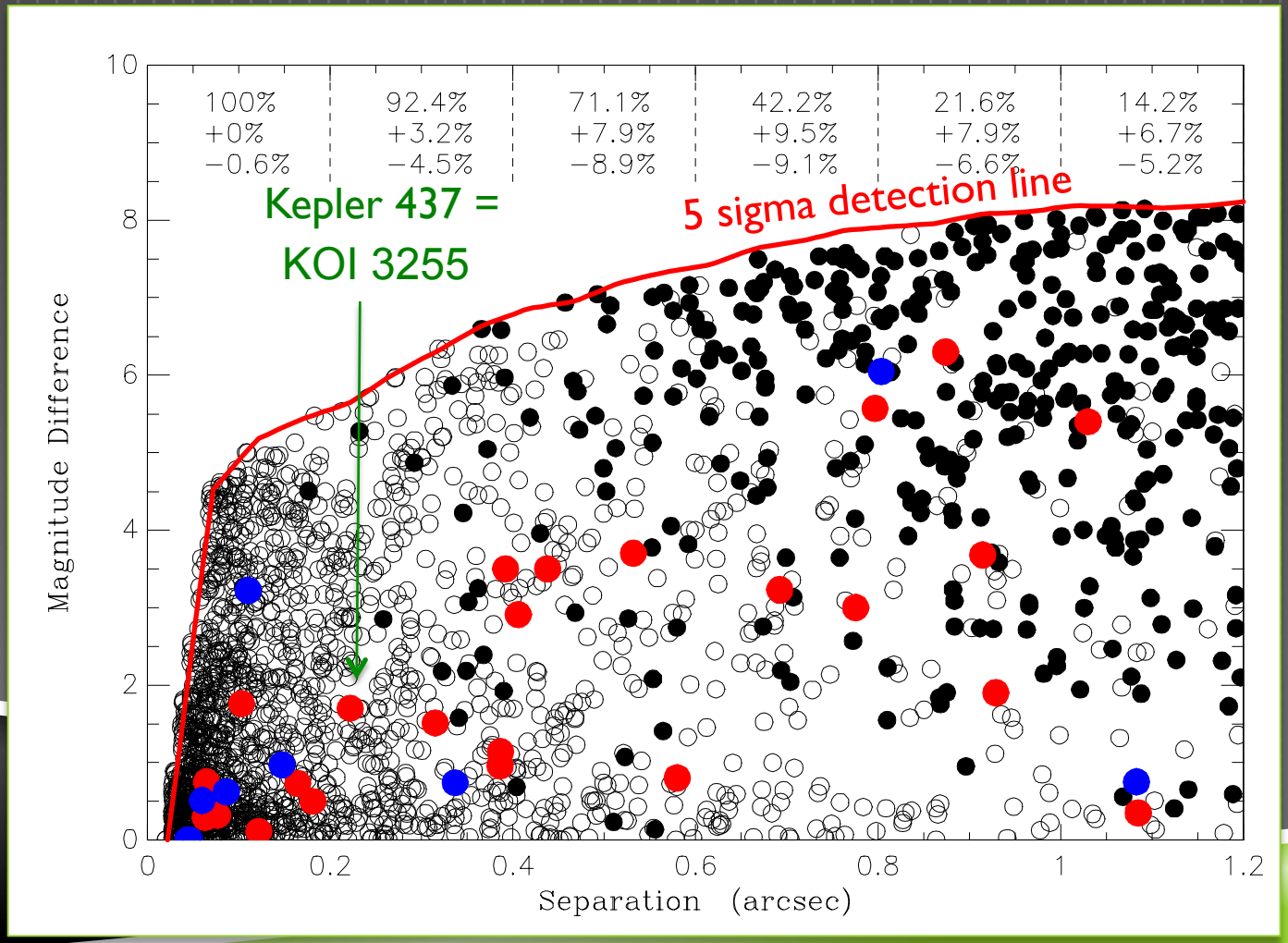
RV AND AO DATA

Wang et al (2014)



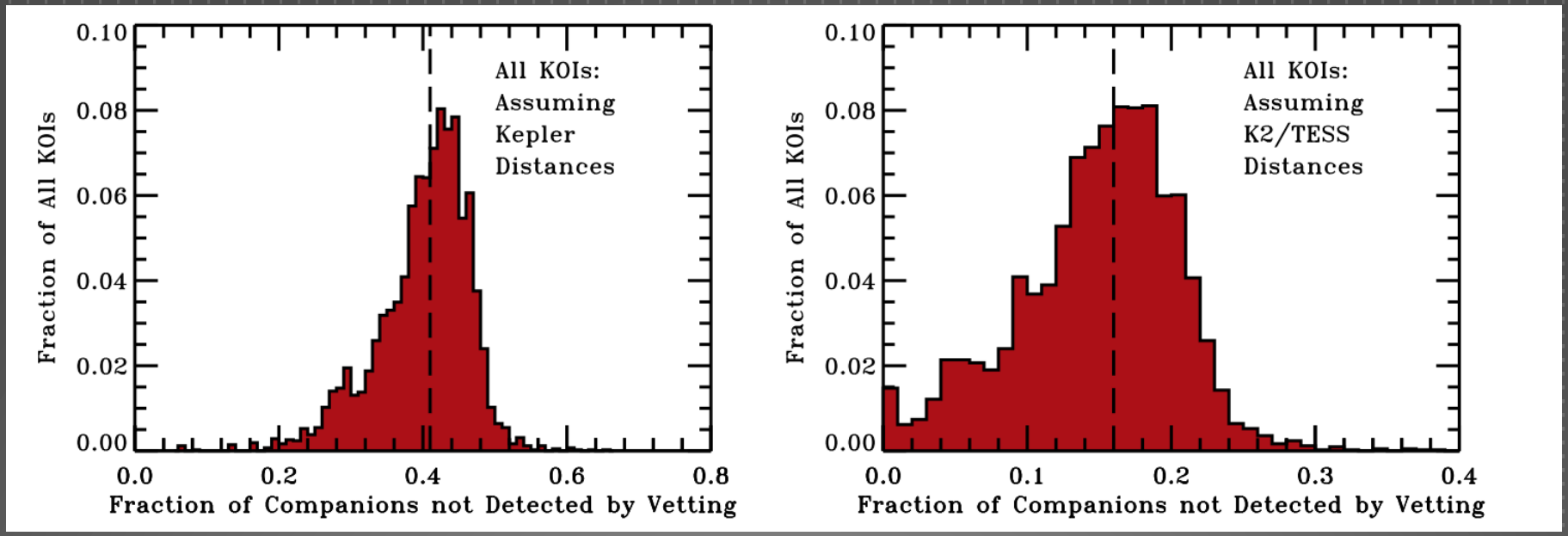
Truncated Disk: Second star disrupts the outer part of disk.

GEMINI: KEPLER STARS WITH COMPANIONS



FINDING COMPANIONS: HOW INCOMPLETE?

Ciardi et al 2015

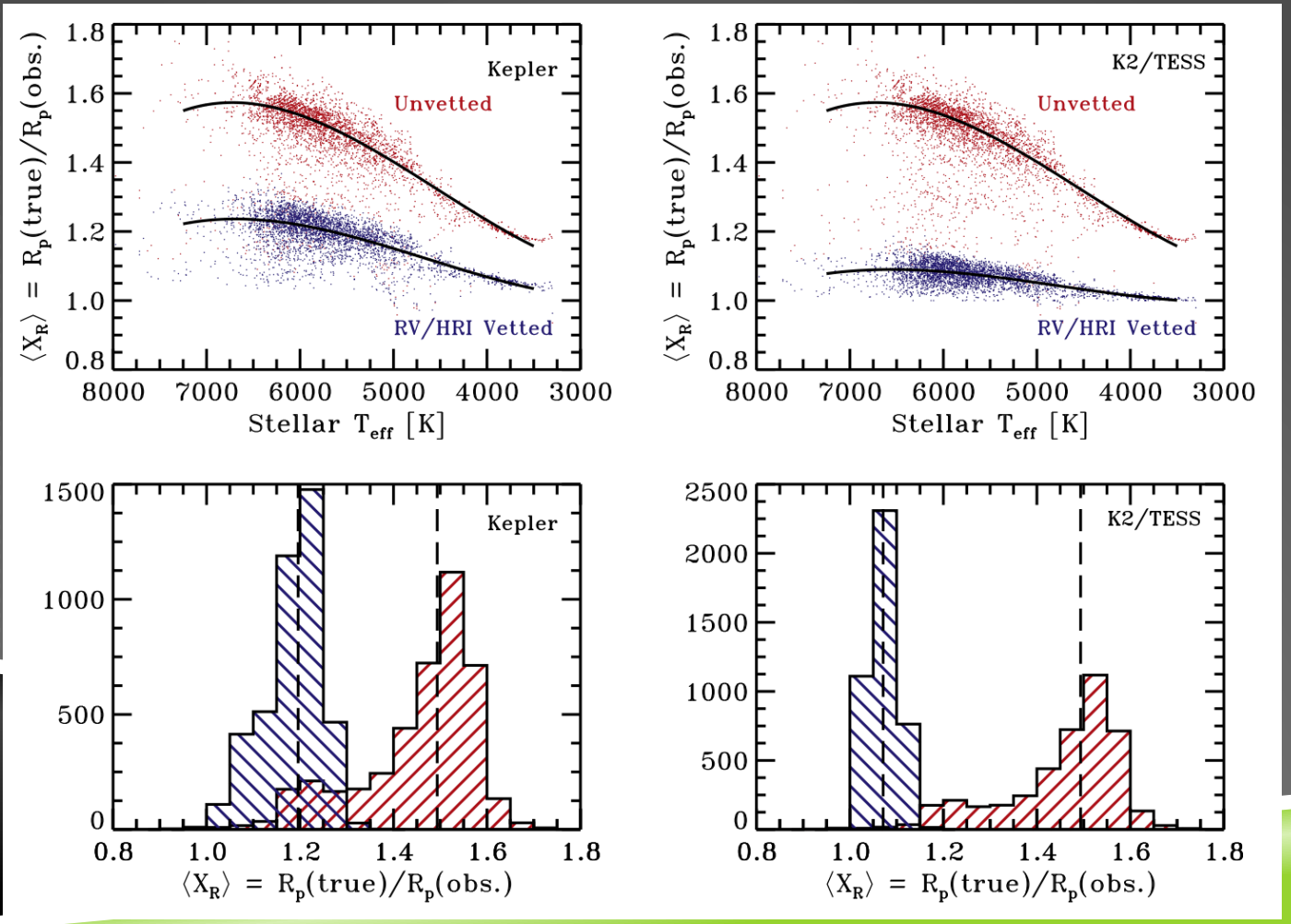


For K2/TESS distances, significantly fewer companions are missed using the standard techniques.

This is good news!
A concerted observational effort can get us the data we need.

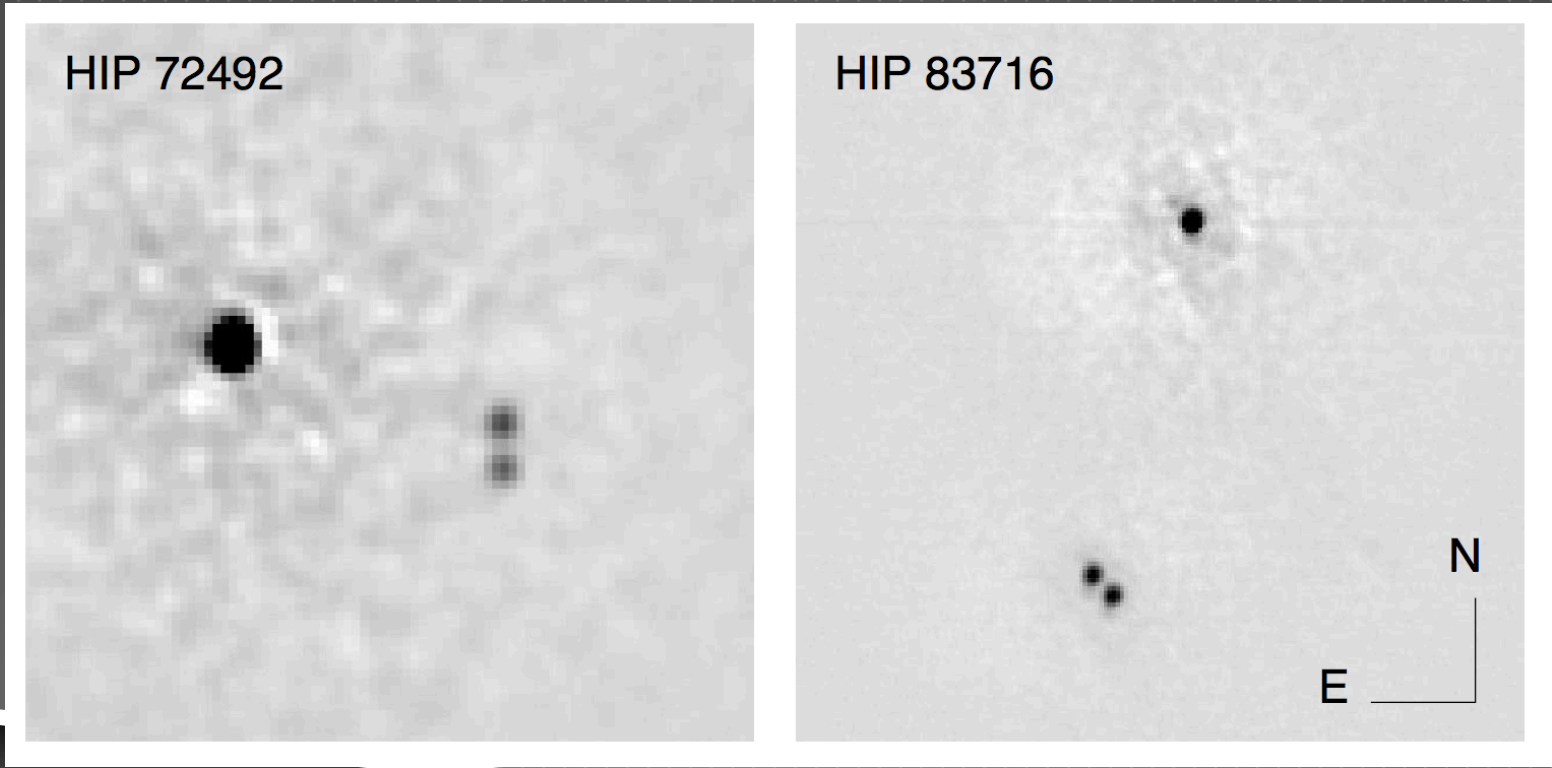
GETTING THE RADIUS RIGHT

Ciardi et al 2015



HOW ARE WIDE DOUBLES FORMED?

Tokovinin and Horch (Data from DSSI Queue run Gemini-S, June 2017).

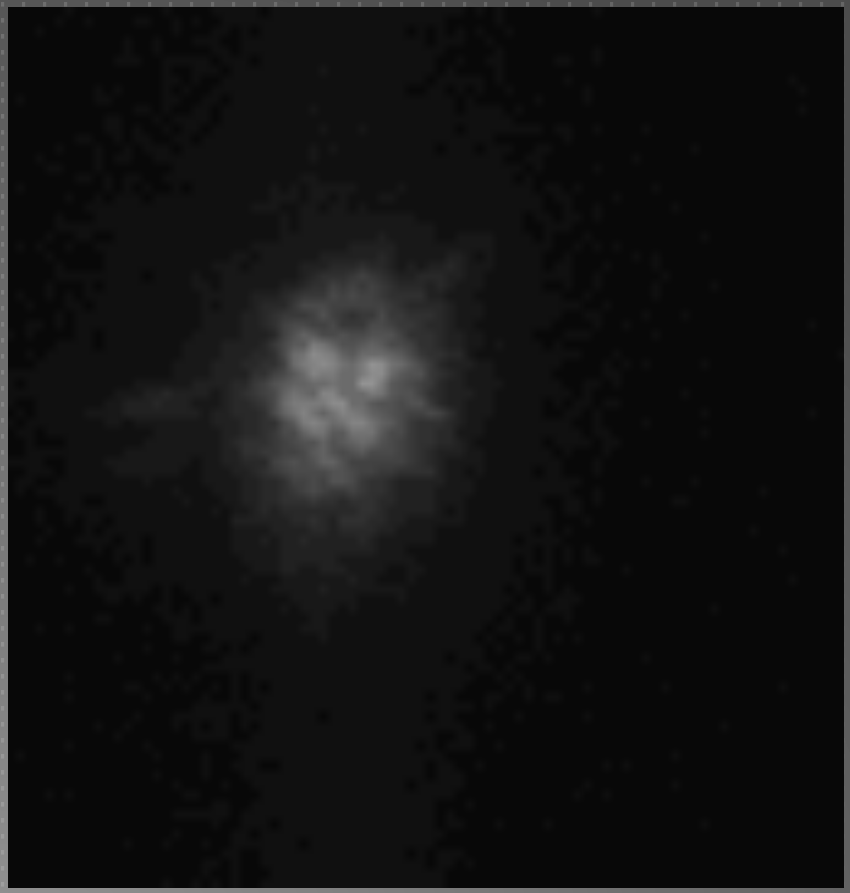


Fragmentation: more wide components are themselves binary. A-BC architecture, as above.

Ejection: fewer BC's.

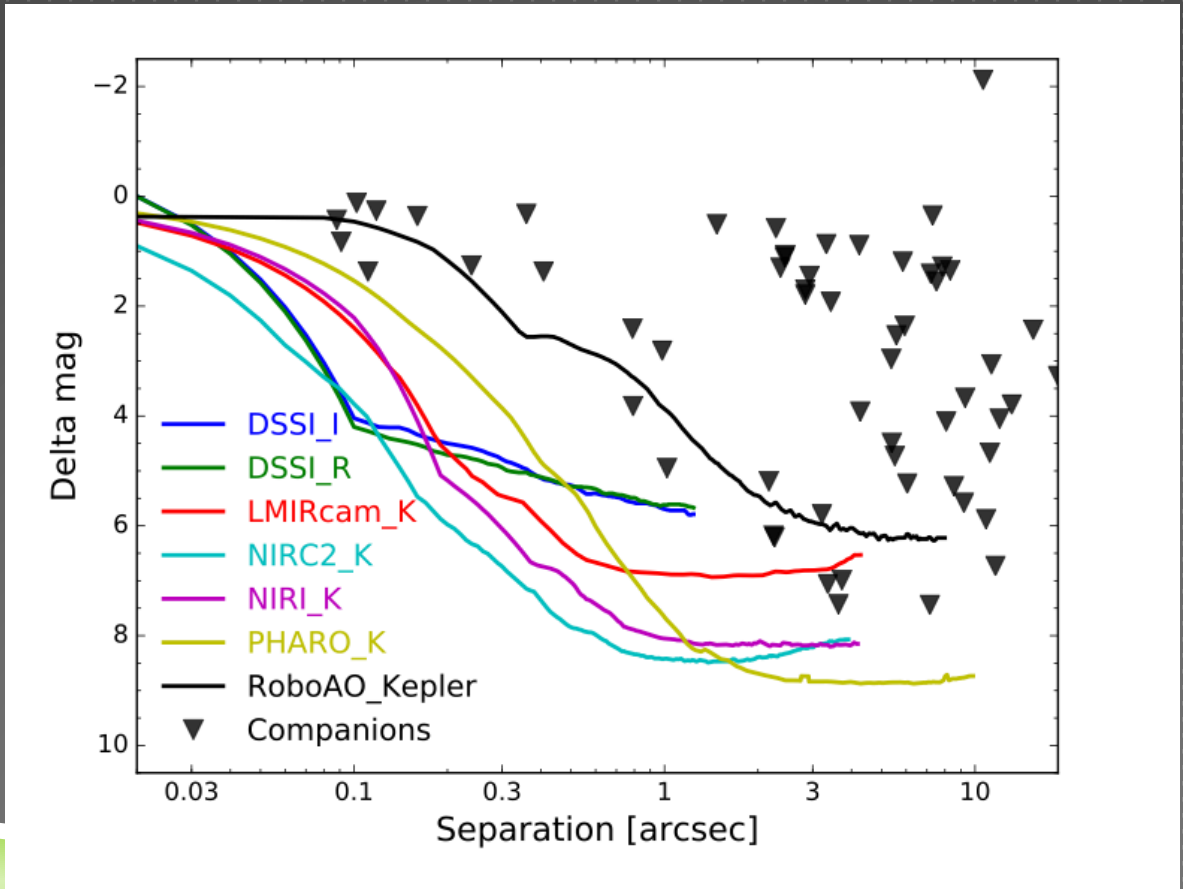
K2, TESS AND IMAGING

- As with Kepler, ground-based vetting is important.
- High-resolution imaging aids exoplanet host star follow-up observations.
  - Which planets hosts are binaries?
  - How often is there a stellar companion?
  - What is the radius of the planet?
  - What are the properties of stellar companions?
- Ground-based imaging
  - AO
  - Speckle



COMPANION DETECTION FOR K2 USING AO AND SPECKLE

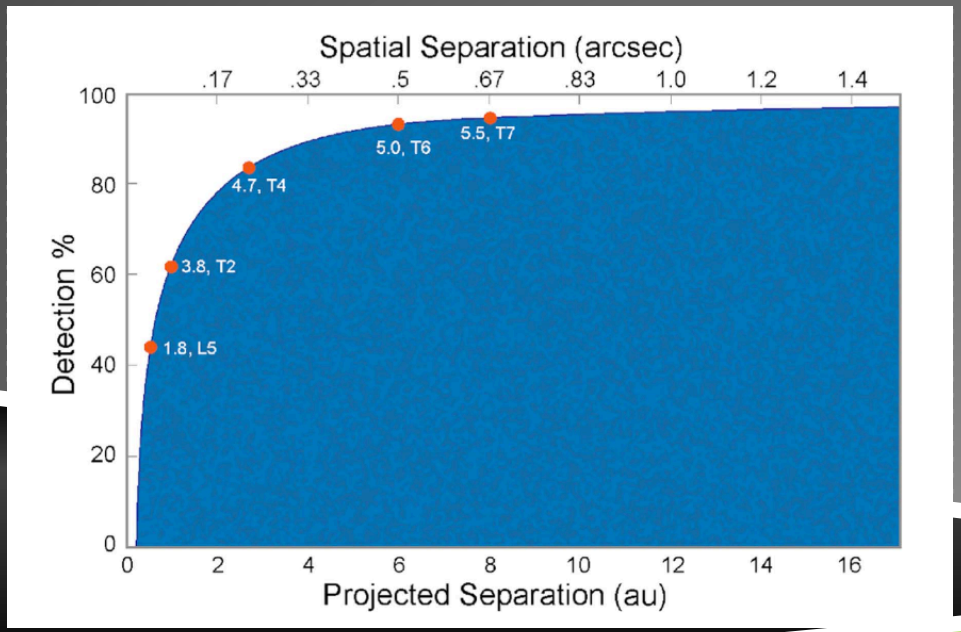
Crossfield et al. 2016, 5σ confidence limits

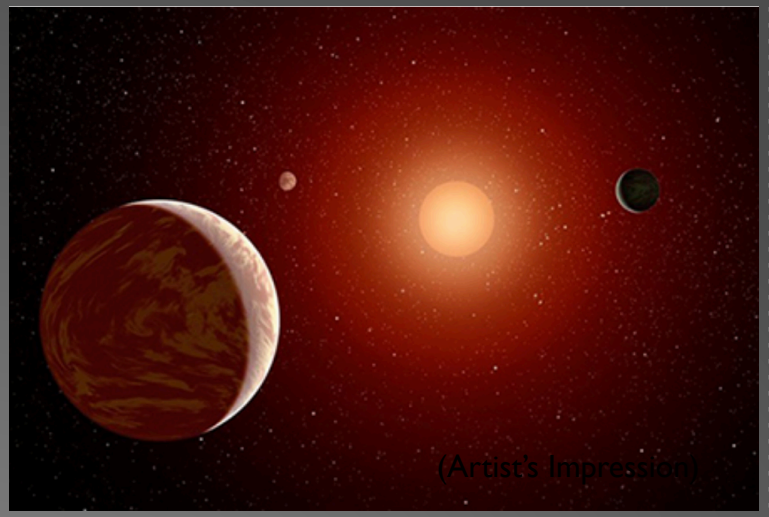


DSSI IMAGING OF TRAPPIST-1

Gemini Observatory Press Release, September 2016

A system of 7 planets orbiting a late M dwarf that is 12pc away from us. 3 planets in the HZ.



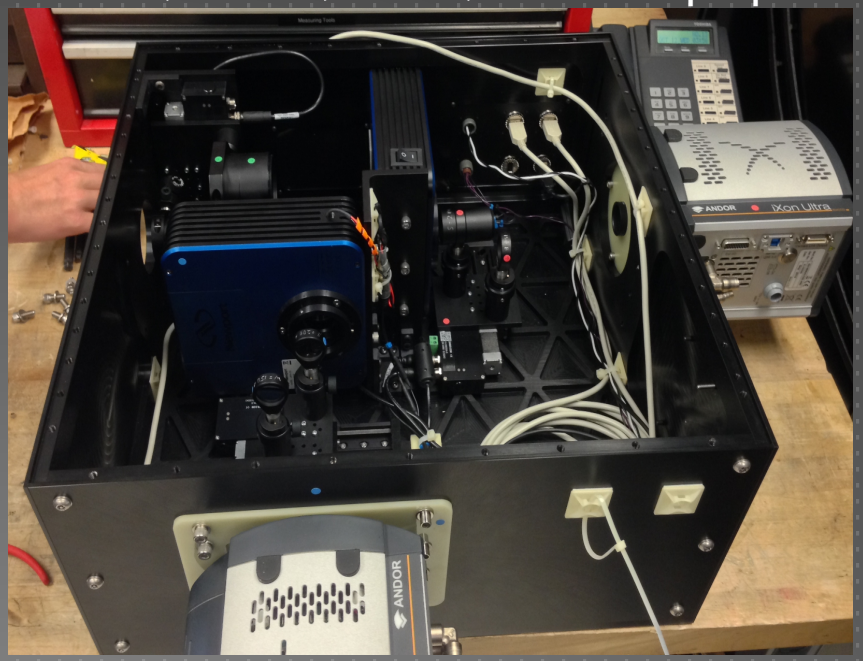


DSSI found no stellar companions down to a separation of <0.5 AU. (Howell et al. 2016.)

NEW SPECKLE CAMERAS TO SEARCH FOR STELLAR COMPANIONS

Scott, Howell, Horch, Everett in prep

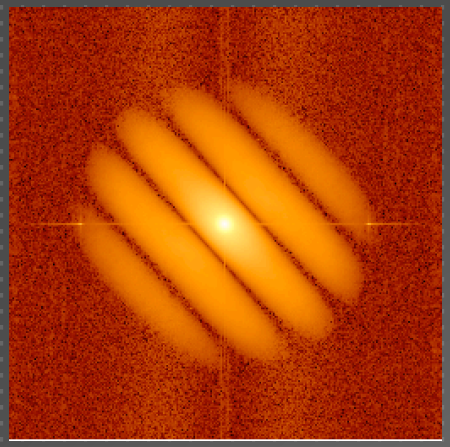
- Commissioned in October 2016.
- Queue time available to the community via the NN-Explore Program at NOAO (same deadlines as normal NOAO proposals).
- ***"DSSI 2.0:"***
  - Filter wheels, larger filter selection
  - 1024x1024 (& faster) detectors
  - Two magnifications:
    - Normal Speckle (0.018"/pix)
      - Wide Field (0.081"/pix)

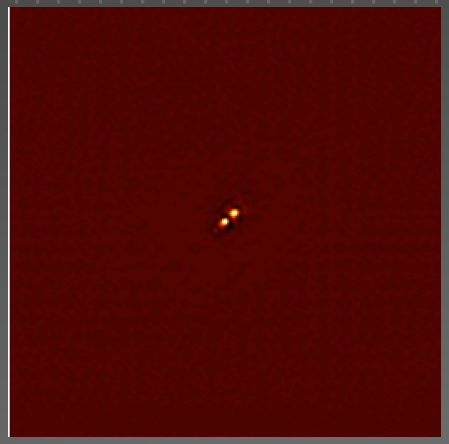


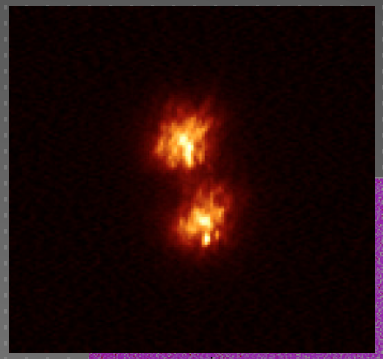
NESSI at WIYN prior to mounting to the telescope during the commissioning run. (photo credit: NOAO website)

NESSI @ WIYN and
'Alopeke @ Gemini-N

NESSI LIVES!!

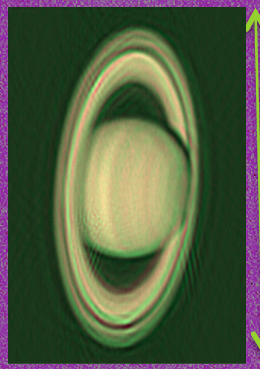






SPECKLE MODE: Power spectrum and Reconstructed image of STT 535 (sep~0.1")

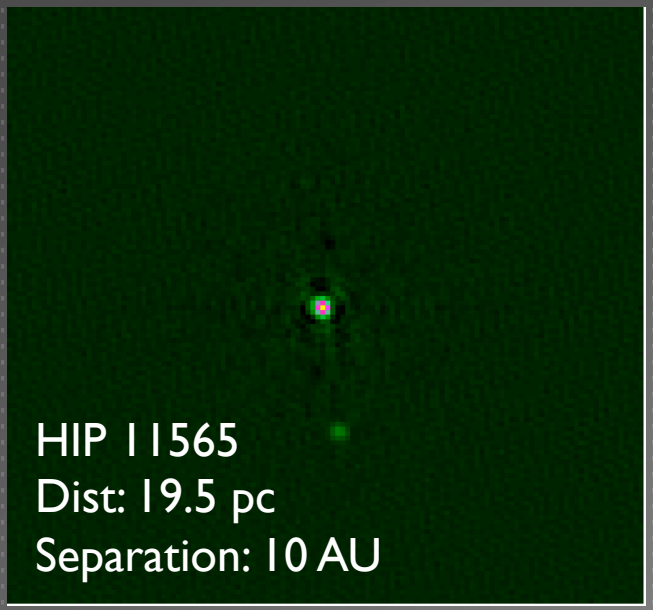
WIDE FIELD MODE: a 40-ms full-frame of Saturn, and inset, a blow-up of a 2.4" binary (40 ms).



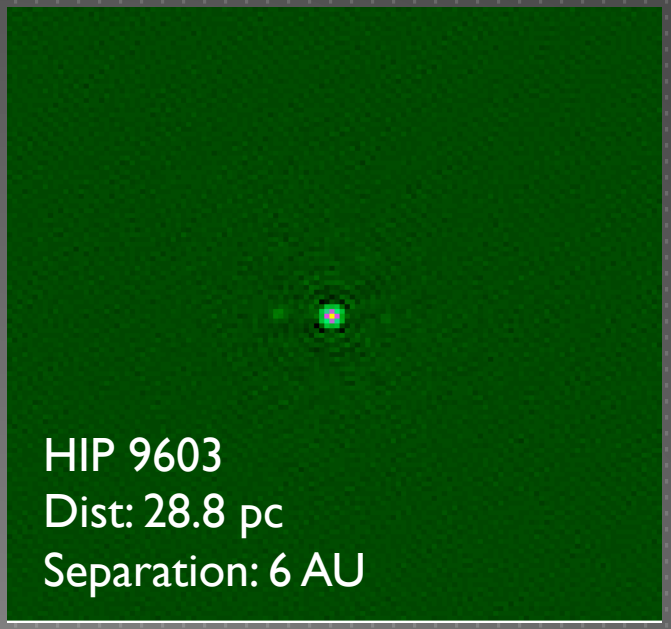
See poster by Casetti et al

STUDYING BINARITY AS A FUNCTION OF SPECTRAL TYPE – K-KIDS

Data from Lowell Observatory's Discovery Channel Telescope



HIP 11565
Dist: 19.5 pc
Separation: 10 AU



HIP 9603
Dist: 28.8 pc
Separation: 6 AU

See Posters by:
Paredes et al, Nusdeo et al.

STUDYING BINARITY AS A FUNCTION OF SPECTRAL TYPE – M DWARFS

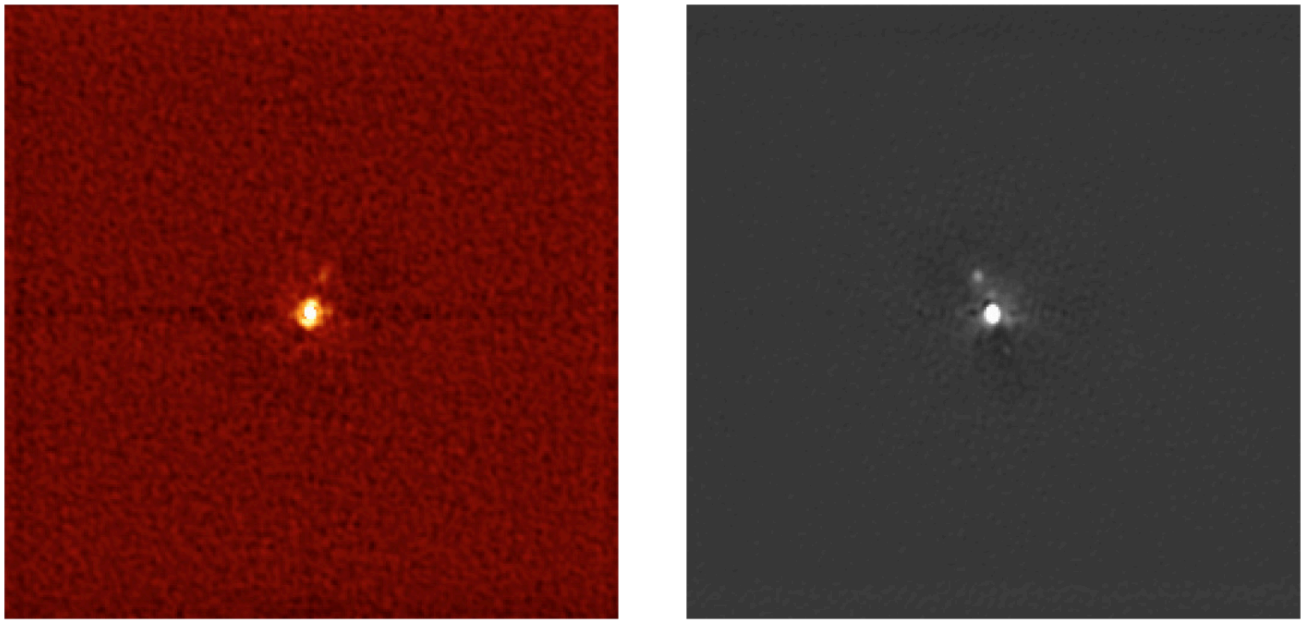


Fig. 1.— Reconstructed images for LP848-050 obtained on 14 Jan 2016 UT. (a) 692 nm. (b) 880 nm. (The internal ID for this object is H640070.) $V = 16.53$!!

See poster by Jen Winters (CfA)

SUMMARY

- Companion detection and characterization remains a vital issue with K2 and TESS.
  - DSSI: 9 years of exoplanet host star observations and still chugging away.
  - NESSI, 'Alopeke: "next generation" variations on the DSSI idea, with a Wide Field mode.
- Opportunity: with closer systems under study, more overlap in RV, HRI techniques, more complete samples can be constructed and studied.
  - Orbital properties
  - Stellar properties.
- Complete K and M dwarf surveys are being carried out that will "prevet" stars for future exoplanet studies.