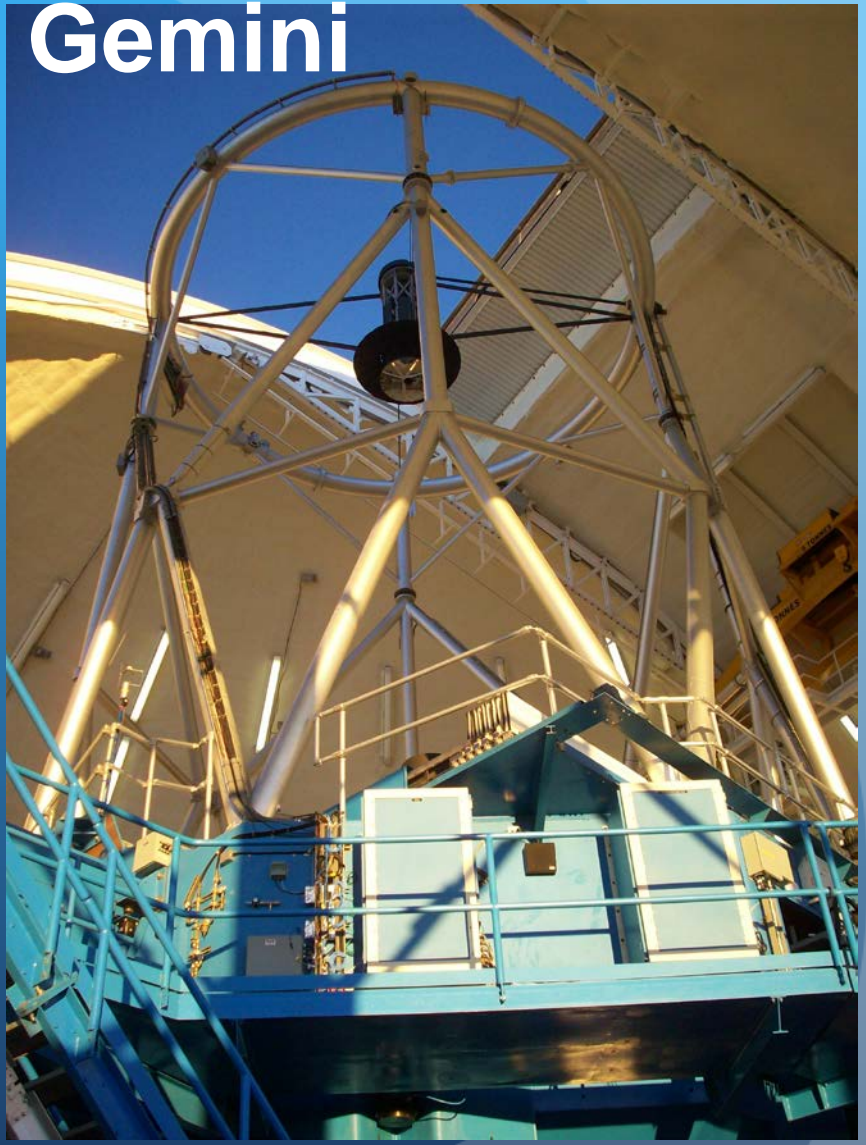


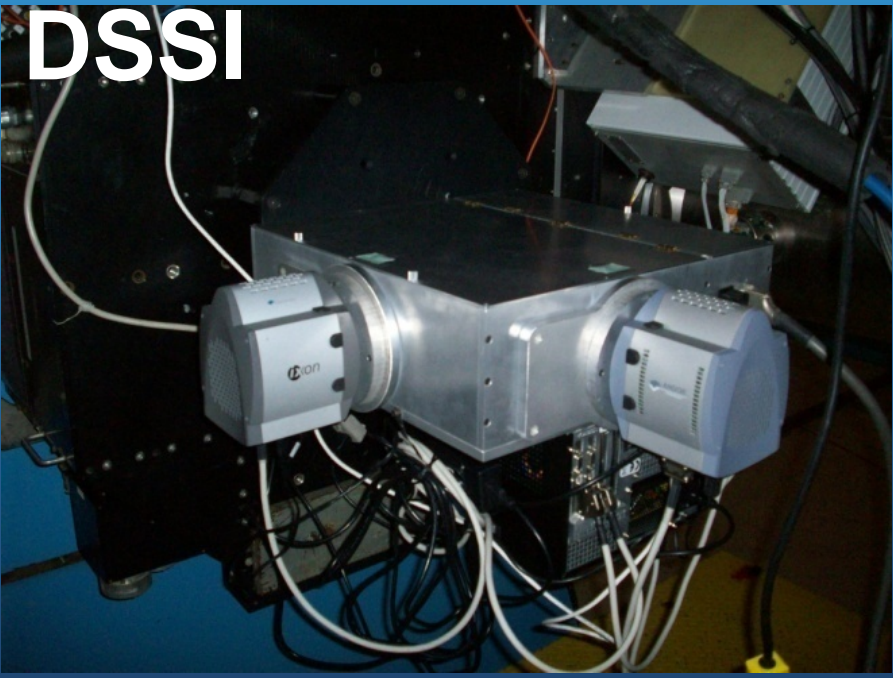
Speckle Imaging with DSSI at Gemini and the DCT

Elliott Horch, SCSU

Gemini

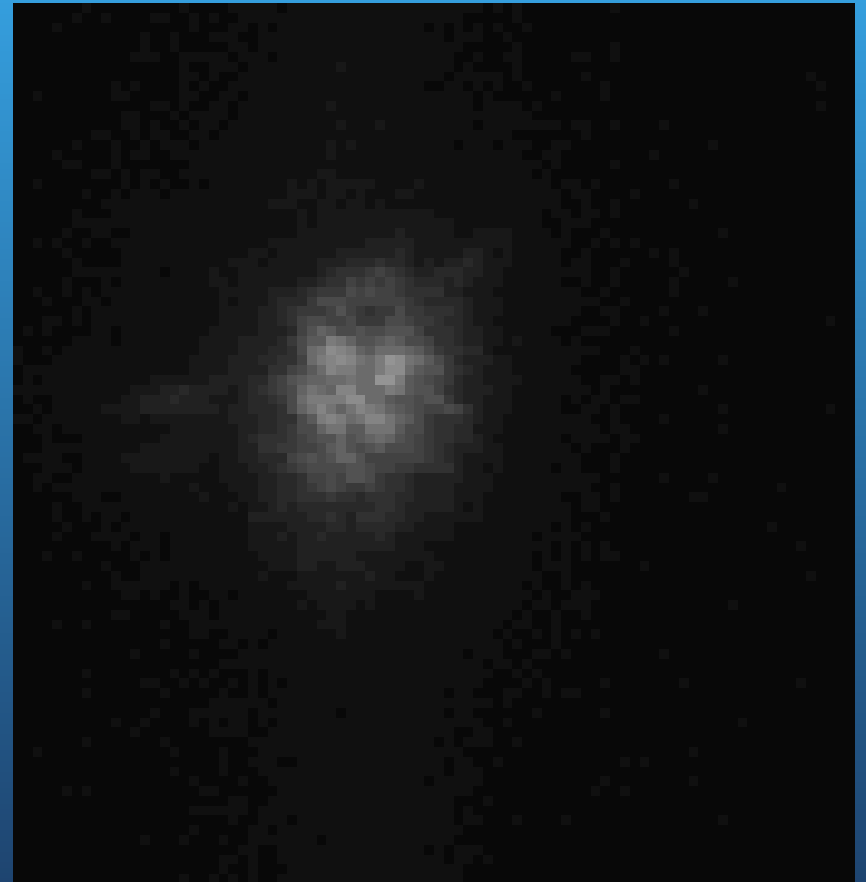


DSSI



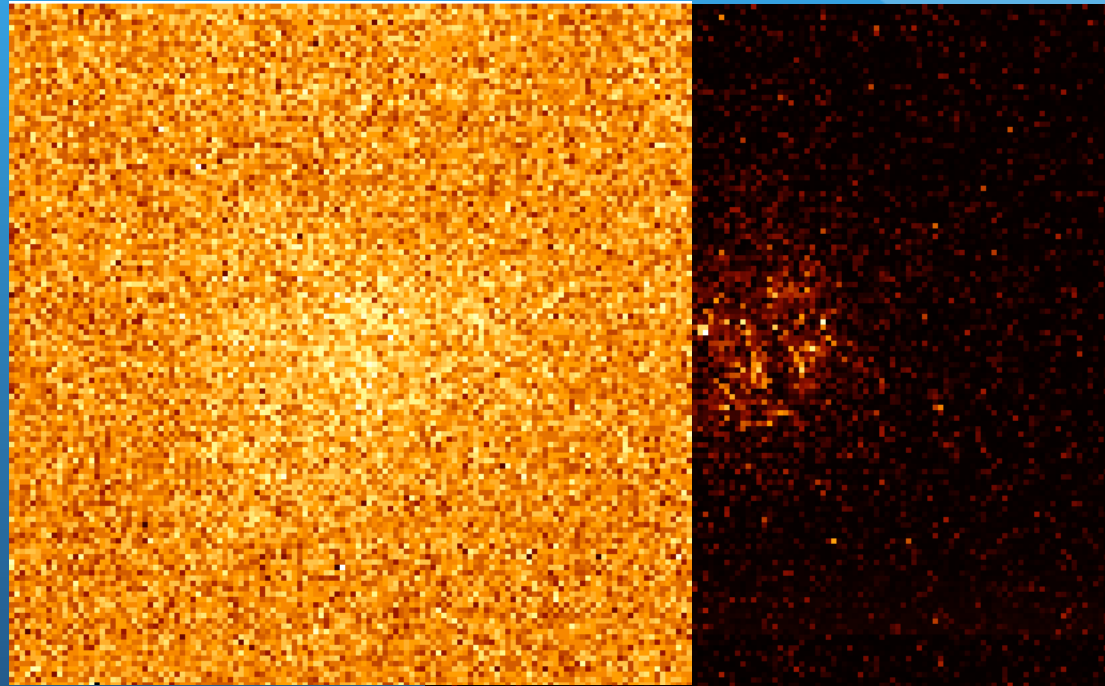
Speckle Imaging is “Single-Aperture” Interferometry

- In each exposure, the effect of atmospheric turbulence is “frozen.”
- If the object is double, then there are “double speckles.”
- Image reconstruction via bispectral analysis.
- Fast: no observing overhead.
- Baselines are redundant.
- Speckle has been responsible for many high-quality binary star orbits over the years.



EMCCDs

Photon counting performance with high quantum efficiency.

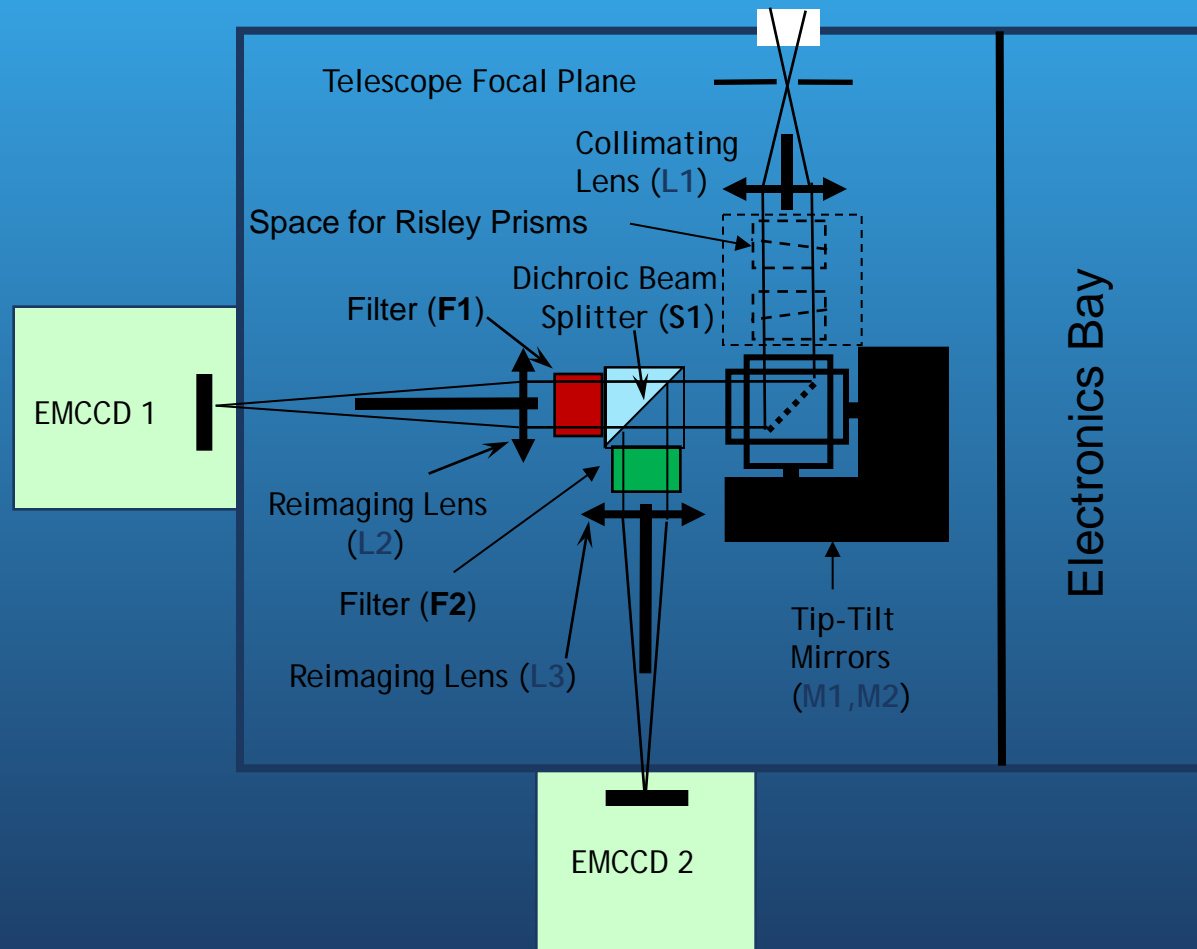


Clocking accumulated charge through a series of gain registers builds up signal prior to reading out through the charge amplifier → sub-electron read noise.

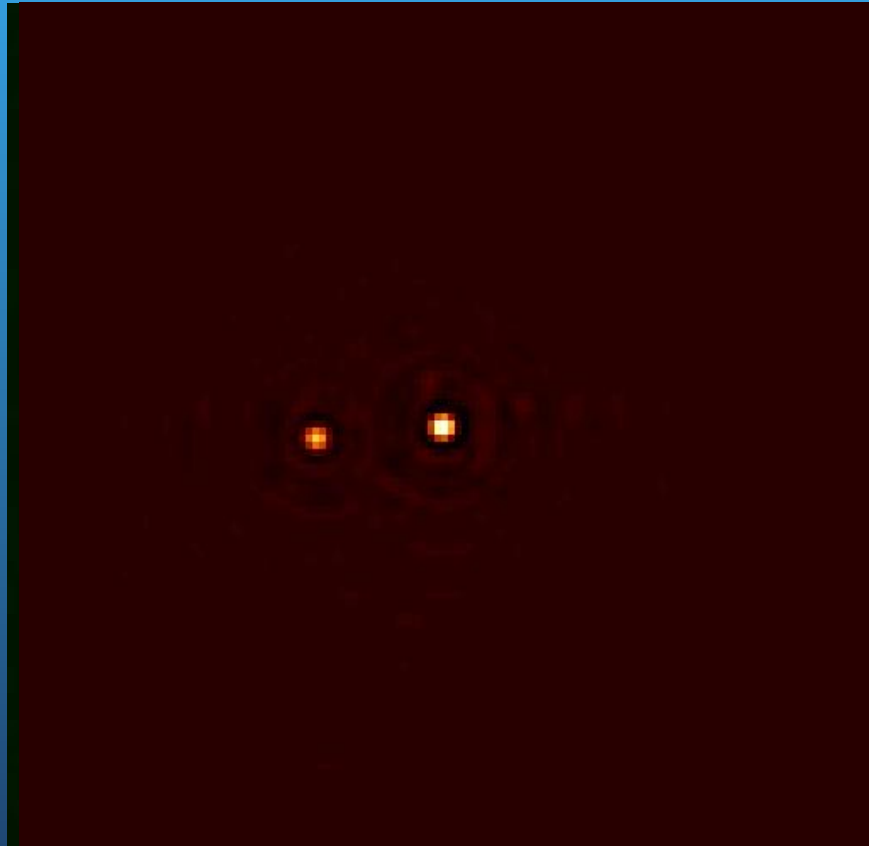
Some Speckle Cameras in Current Use

Camera	Detector Type	Principal Investigator(s)	Telescope(s)
USNO Speckle Camera	ICCD	W. Hartkopf, B. Mason	USNO 66-cm refractor, Kitt Peak 4-m, USA
HRCam	EMCCD	A. Tokovinin	SOAR 4.1-m, Chile
SAO Speckle Camera	EMCCD	Y. Balega	SAO 6-m, Russia
DSSI	Dual EMCCD	E. Horch	WIYN 3.5-m, DCT 4.3-m, Gemini-N and -S 8.1-m, USA
PISCO	ICCD	J.-L. Prieur, M. Scardia	Zeiss 1-m, Merate, Italy

A Uniquely Capable Speckle Imager Built at SCSU

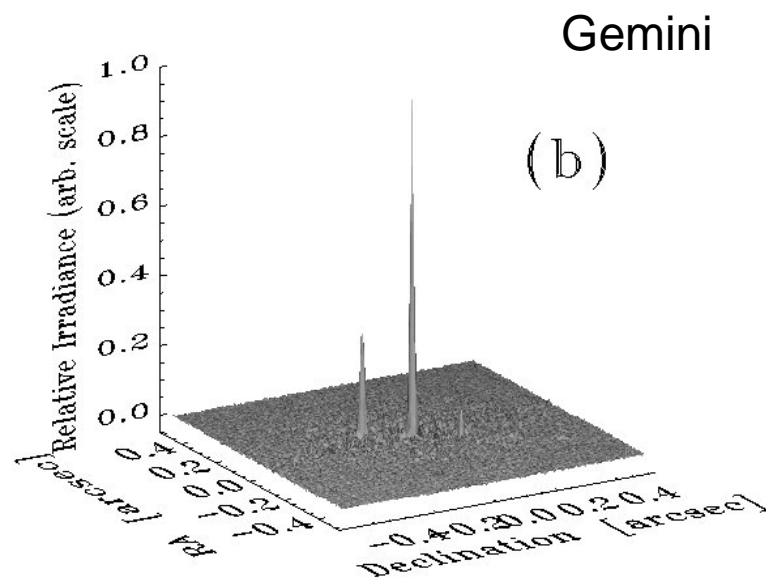
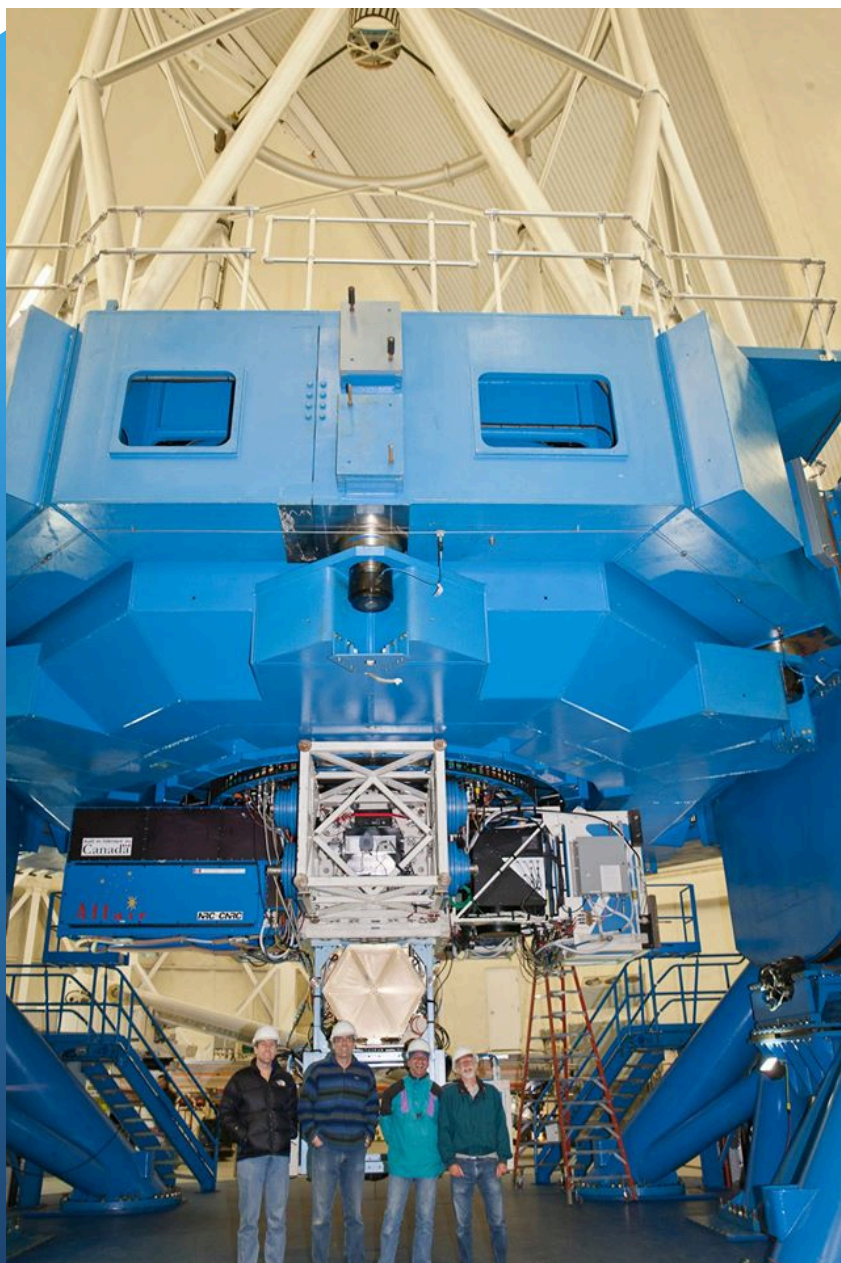


What the DSSI Camera Does



Gemini-N

Used 2012-present, official visiting instrument, 4 different science projects on last run. (Jan 2016)

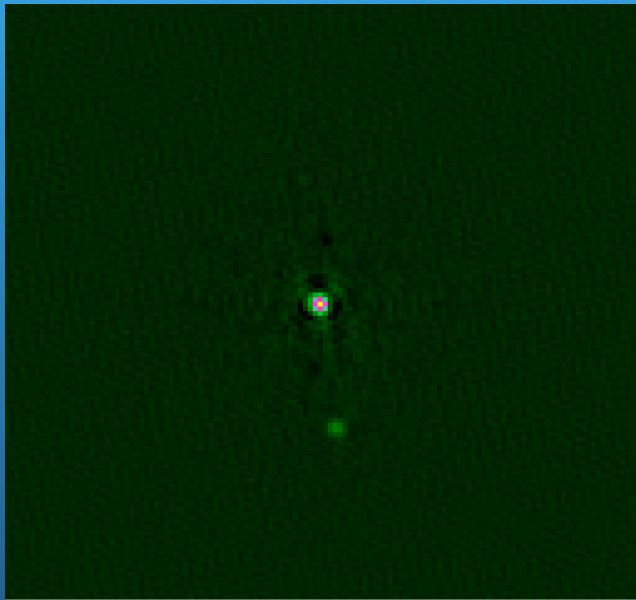


Some Representative Projects

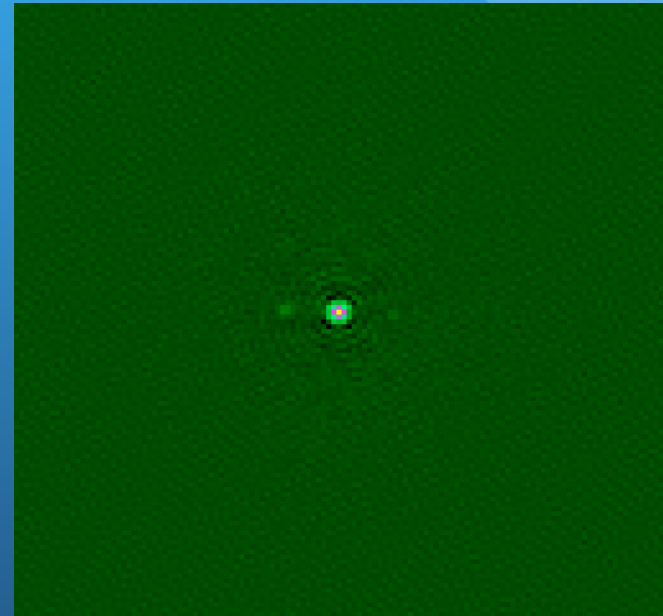
- K-Kids. Finding companions to K-type main sequence stars.
 - GOAL: G, M stars have been characterized but not K stars. If the rate of binarity is different for K stars, it will have implications for star formation. (*T. Henry, E. Horch*)
- Kepler survey. Finding companions to KOIs and K2 objects.
 - GOAL: Characterize fraction of exoplanet systems that have *stellar* companions. (*S. Howell, E. Horch*)
- Observing secondaries of known “wide” binaries – finding companions. (*A. Tokovinin, E. Horch*)
 - GOAL: will yield info on star formation processes.
- Metal-Poor Binaries. (*W. van Altena, P. Demarque, E. Horch*)
 - GOAL: Characterize “Second Parameters” of Mass-Luminosity Relation.

K-Kids Poster Children of the Month

Data from Lowell Observatory's Discovery Channel Telescope



HIP 11565
Dist: 19.5 pc
Separation: 10 AU

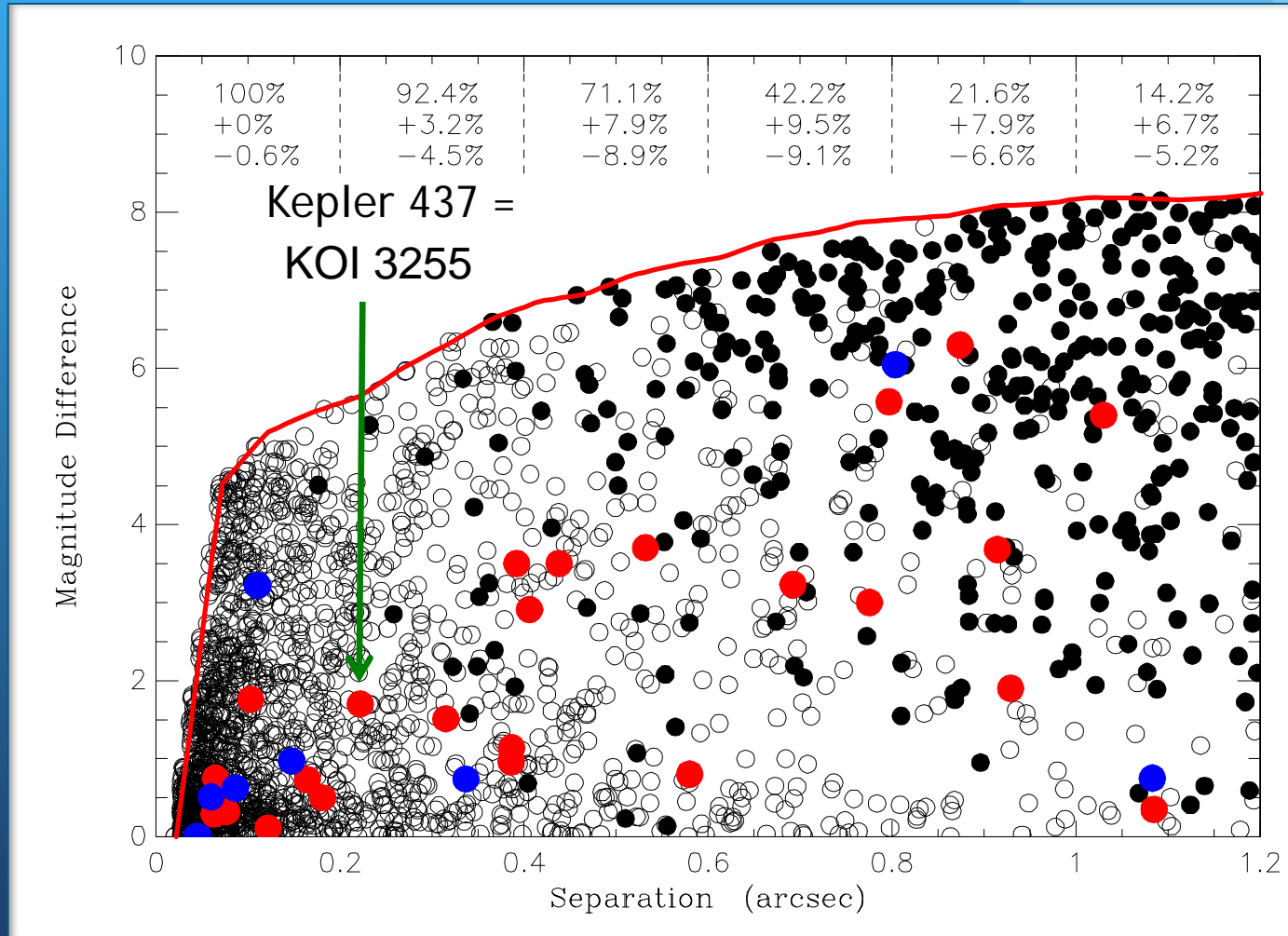


HIP 9603
Dist: 28.8 pc
Separation: 6 AU

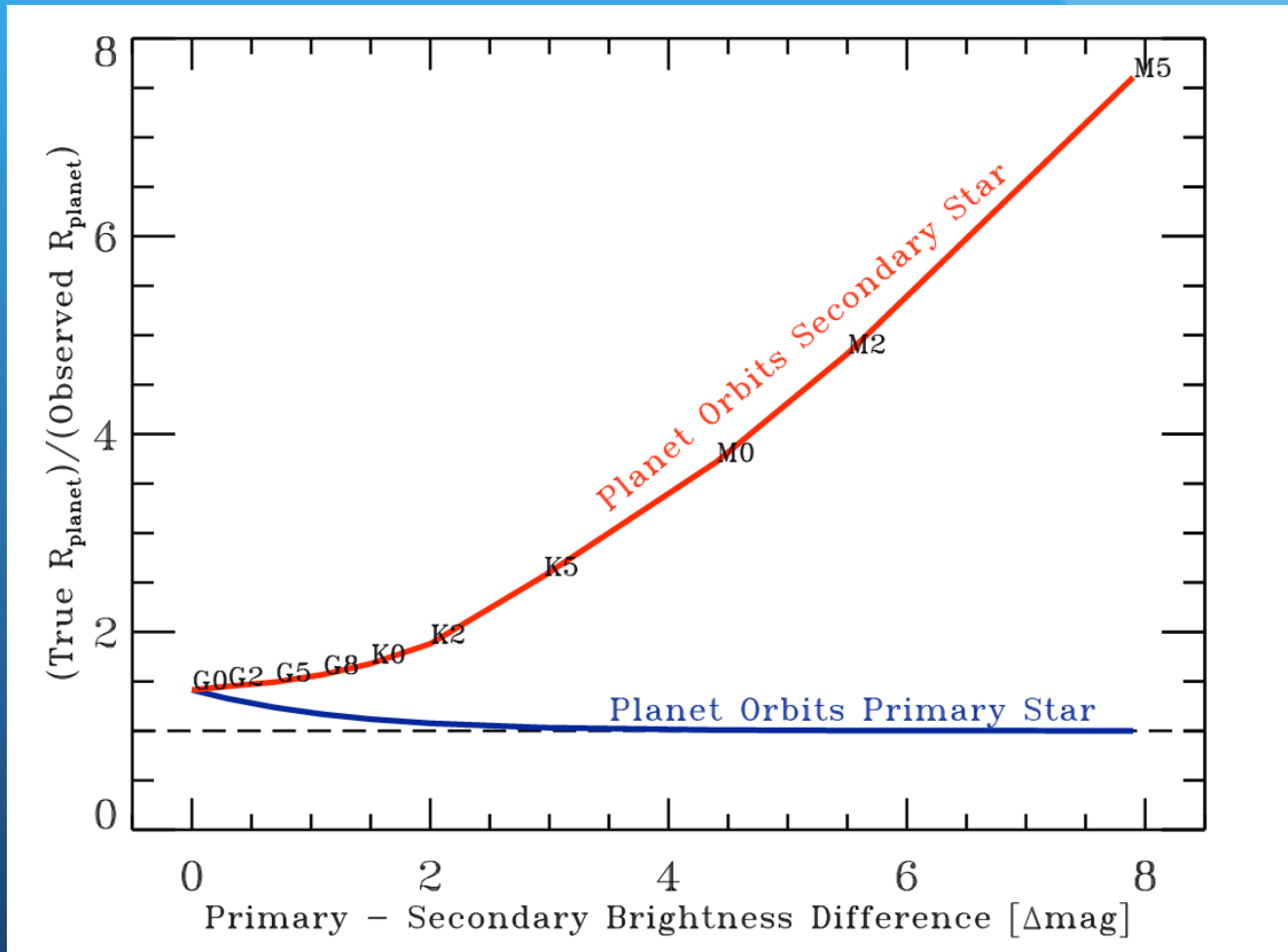
Companion Detection for Kepler

- TRILEGAL galaxy model.
- Look in Kepler field at the appropriate distance range.
- Use Raghavan 2010 binary/multiple star statistics from the field.
- Ask with what frequency DSSI would detect Kepler star with a companion.

Gemini: Kepler Stars with Companions

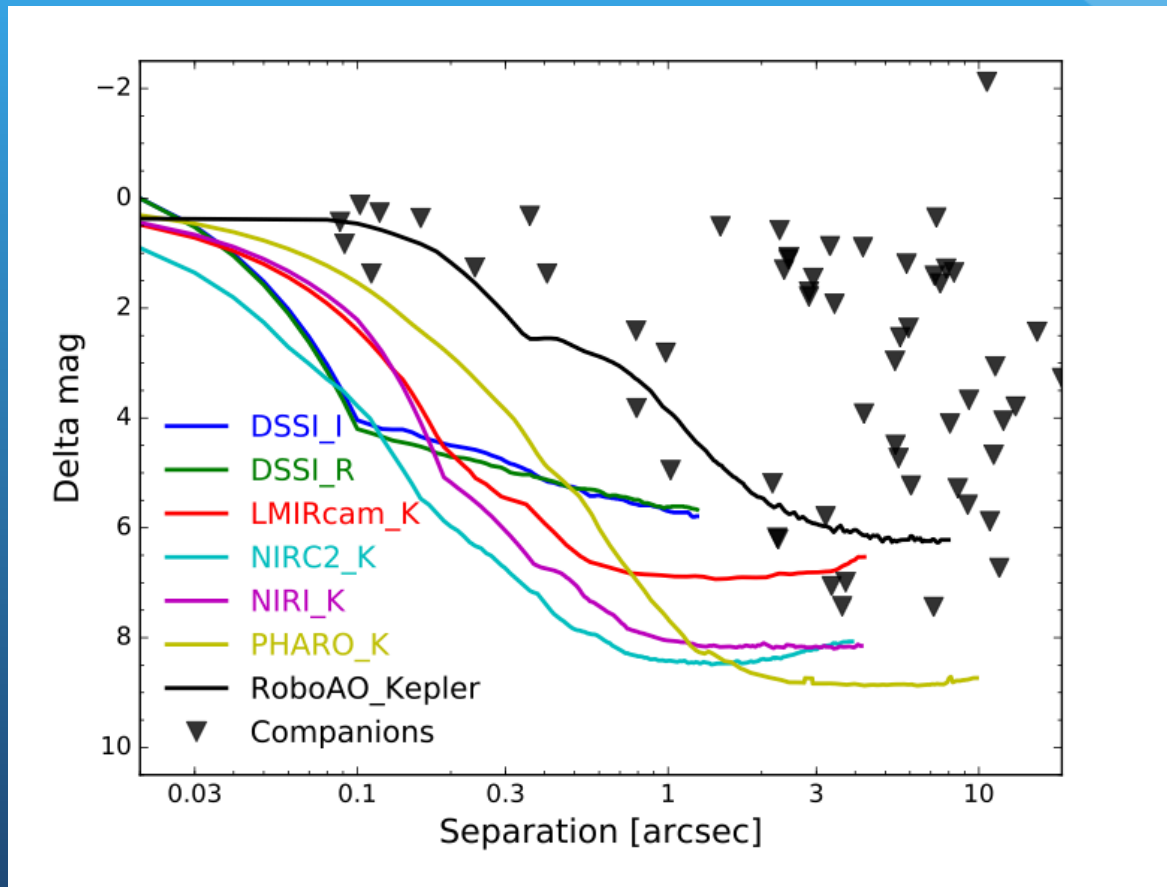


Error In Planet Radius

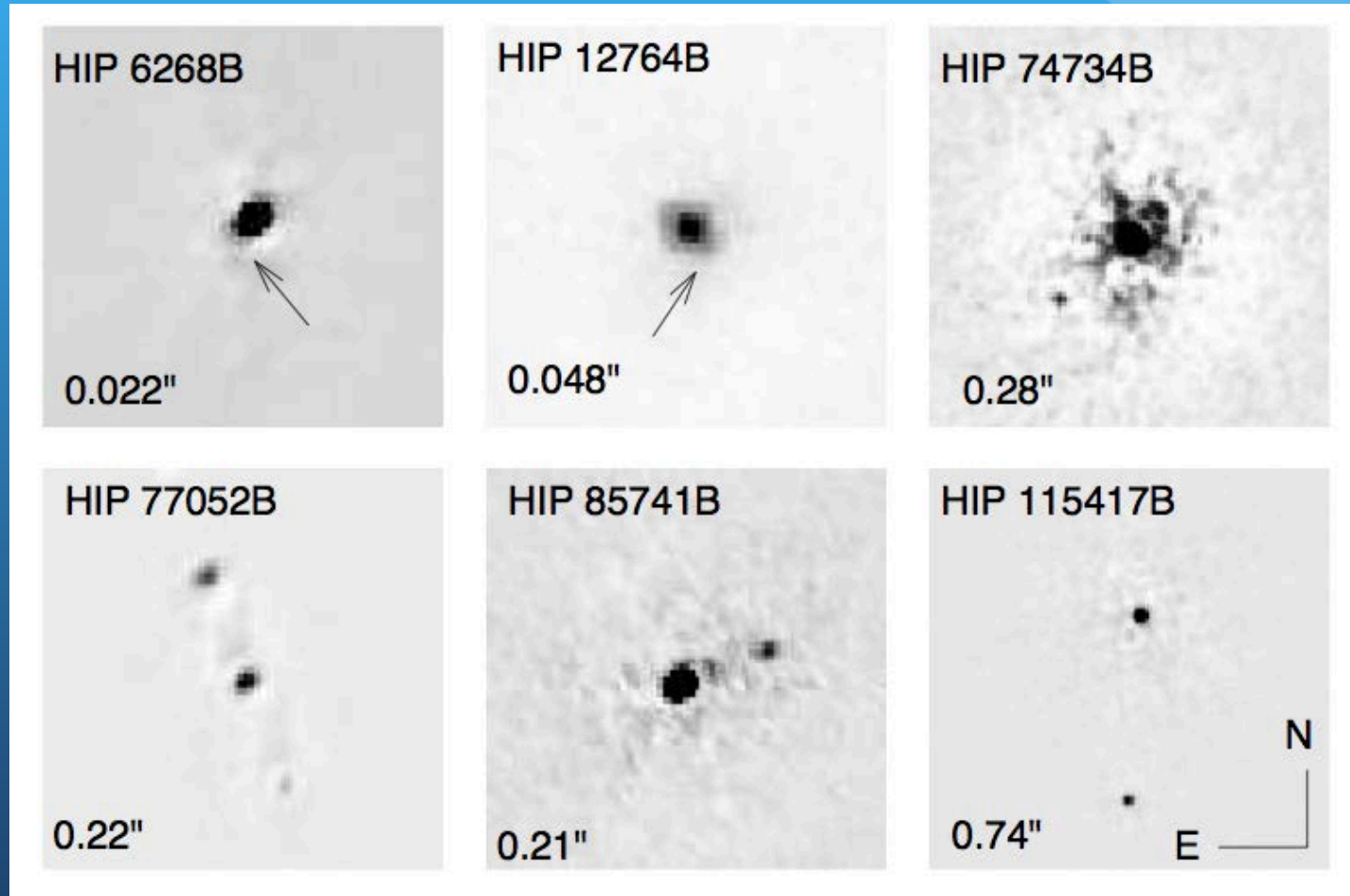


Companion Detection for K2 using AO and speckle

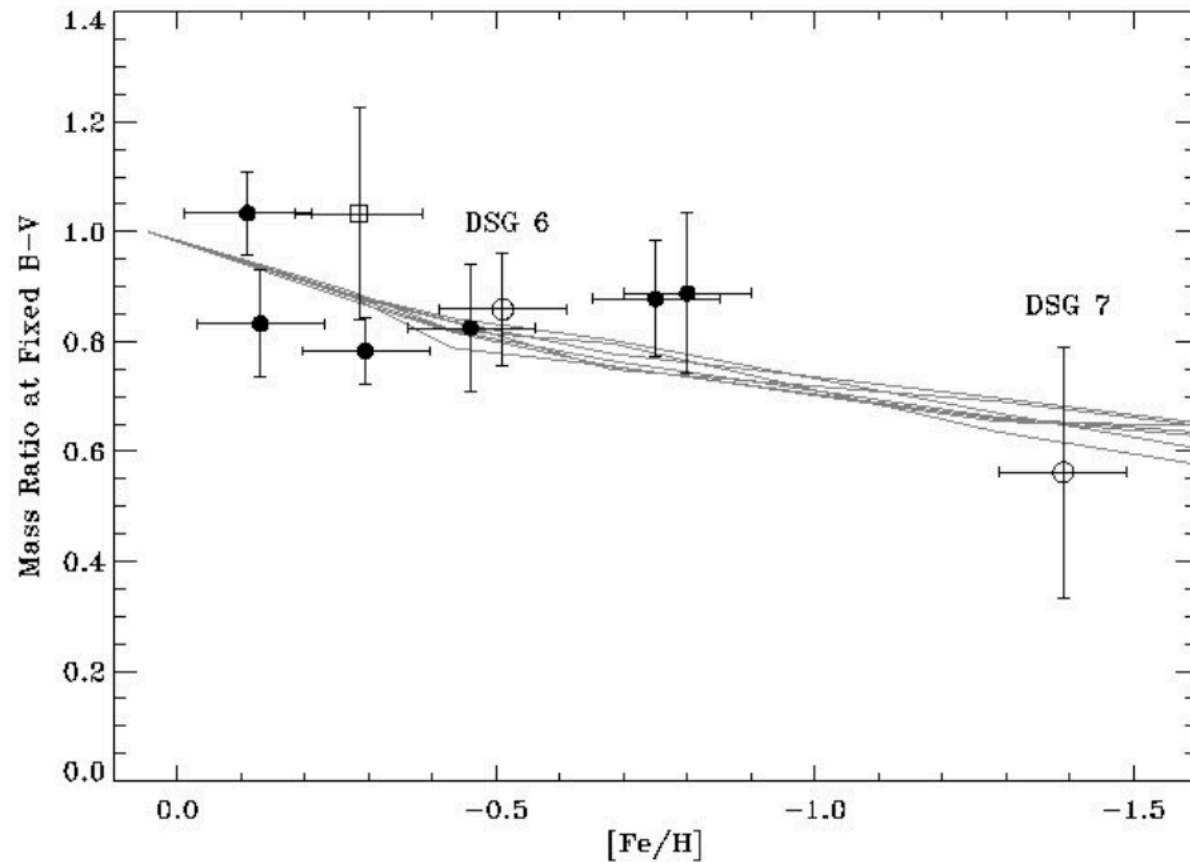
Crossfield et al. 2016, 5σ confidence limits



Andrei's "BCs"



Metal-Poor Binaries



What's new?

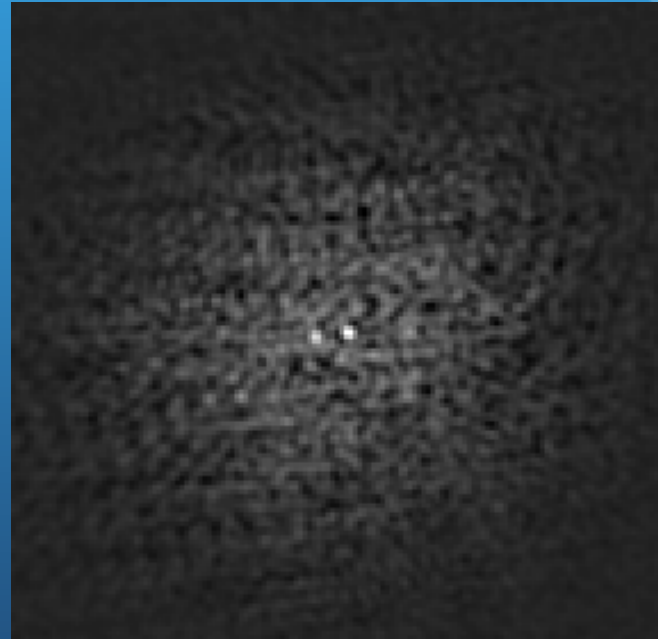
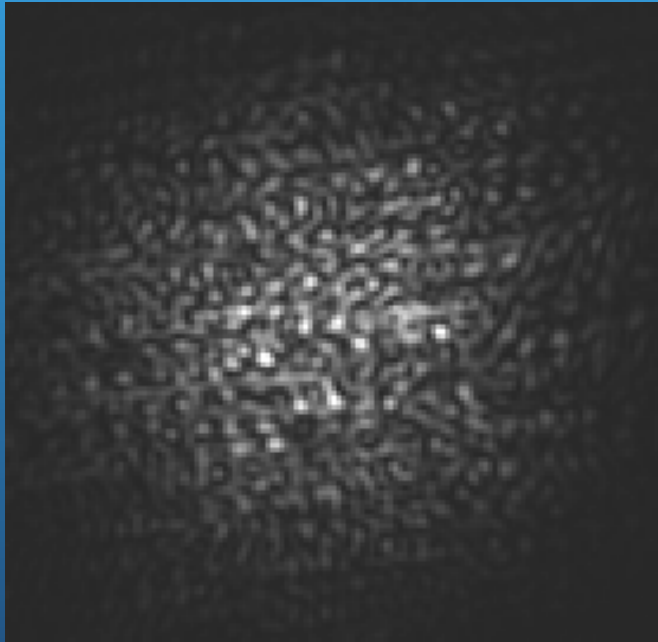
WIYNSPKL and GEMSPKL

- Two new “facility” speckle cameras for WIYN and Gemini-N
 - Dual-channel instruments, like DSSI
 - Both will have a “speckle” mode and a “wide-field” mode (~1'x1')
 - Filters: narrowband speckle filters and Sloan griz.
- WIYNSPKL (aka NESSI): engineering time this October at WIYN. Share port with Hydra, WHIRC.
- GEMSPKL: engineering in Jan 2017? Will mount to GCAL unit, will not take a currently used port.

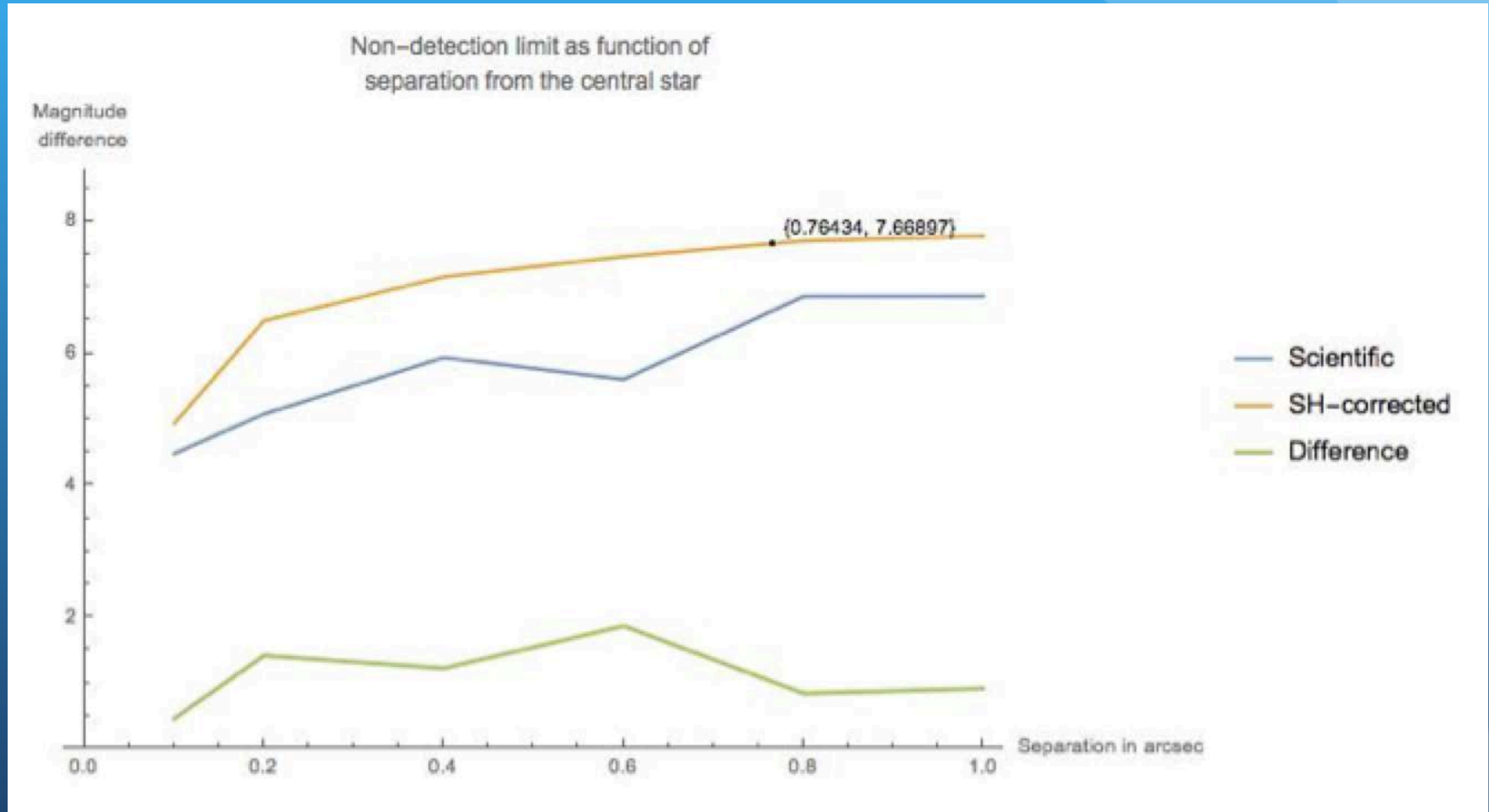
What's New?

Speckle plus Wavefront Sensing

Simulation Results of Löbb, 2016.



Speckle plus Wavefront Sensing



What's New: Gaia

- DR1 was released earlier this month.
 - A few parallaxes of speckle binaries, but in preparing observing proposals for 2017A, I did not find not many.
- When will Gaia help with binaries and astrophysics?
 - DR2 (currently 2017) will contain more and better parallaxes than DR1 but mainly single stars.
 - DR3 (currently 2018) orbits for shorter period binaries.
 - DR4 (currently 2019) first catalog of non-singles.
 - DR5 (currently 2022) full astrometric, photometric, and RV information, final non-single catalogs, exoplanet list.
- While speckle follow-up is unlikely at Gemini in a survey mode, it is a possibility at WIYN, DCT and other 4-m class telescopes.

Summary

- Speckle Imaging today:
 - Success of DSSI has led to the construction of two new speckle cameras available to the community at WIYN and Gemini.
 - Many science projects: Stars are important again!
 - Biggest impact: finding and characterizing stellar companions to exoplanet systems.
- Can we make speckle even better?
 - Incorporate wavefront sensor information.
 - Wide-field fast imaging.
- Speckle follow-up can be used on Gaia binaries in the coming years.