WIDE-FIELD INFRARED SURVEY TELESCOPE

WFIRST

ASTROPHYSICS • DARK ENERGY • EXOPLANETS

THE 2019 WFIRST (CGI)

EXOPLANET IMAGING DATA CHALLENGE

Julien Girard (STScI)
Junellie Gonzalez-Quiles (GSFC)
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Stephen Kane (UCR)
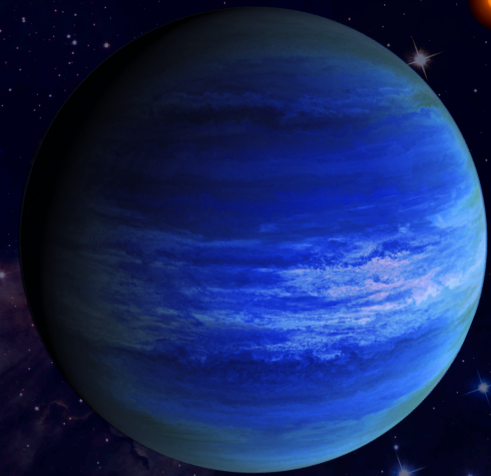Davy Kirkpatrick (IPAC)
Zhexing Li (UCR)
Avi Mandell (GSFC)
Tiffany Meshkat (IPAC)
Maggie Turnbull (SETI)
Neil Zimmermann (GSFC)

Science in our Own Backyard with WFIRST, Caltech, June 20th 2019

DC aims:

- To <u>broaden</u> and <u>deepen</u> our knowledge as exoplanet community

- To get the community acquainted with the CGI data: **new contrast regime** and astrophysics that will be enabled: reflected light giant planets

- To develop, use and improve data simulation and analysis tools, cross-techniques (**)

- To foster collaborations and <u>train</u> future exoplanet scientists!

www.exoplanetdatachallenge.com

WFIRST Exoplanet Imaging Data Challenge
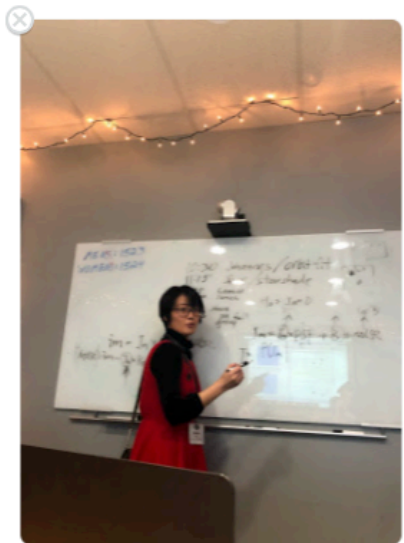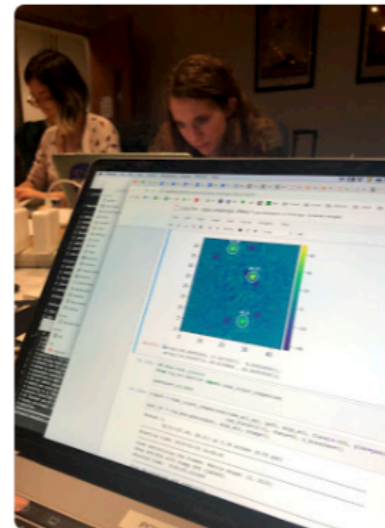
www.exoplanetdatachallenge.com
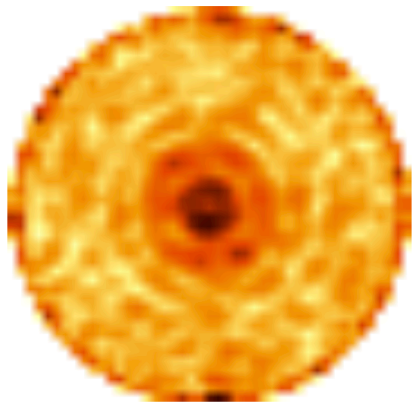
Welcome to the 2019 Community Data Challenge for the WFIRST Coronagraph Instrument, "CGI"

Data challenges aim at engaging the community, to "broaden and deepen" its knowledge.

The **2019 WFIRST Exoplanet Imaging Data Challenge is for exoplanet scientists of all backgrounds and experience levels** who are interested in learning the art and science of high contrast imaging of exoplanetary systems. Opportunities include the Challenge itself, plus associated "hackathons." This is an excellent way to get involved with the intricacies of the first spaceborne high contrast exoplanet imaging mission, as a pathfinder to future flagship missions.

| March Hackathon | ⟹ | June Hackathon | ⟹ | DC Kick Off: October | ⟹ | DC Deadline: December |

"REHEARSAL" HACKATHONS

2019 WFIRST **EXOPLANET IMAGING** DATA CHALLENGE

Scope of this year's challenge
- 6 imaging epochs of the same target throughout mission: 47 Uma
- At least 1 planet has matching and realistic radial velocity data
- Extract sources, compute relative photometry & astrometry, disentangle with background sources, exozodiacal light
- Compute orbital solution using all the information available

Different Entry points
- Work from "scratch": co-added images
- Starting from a reduced table of astrometry and flux ratios: Orbit fitting and albedo inference

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2019 **CGI** DATA CHALLENGE: **MODES**

3+1 Modes
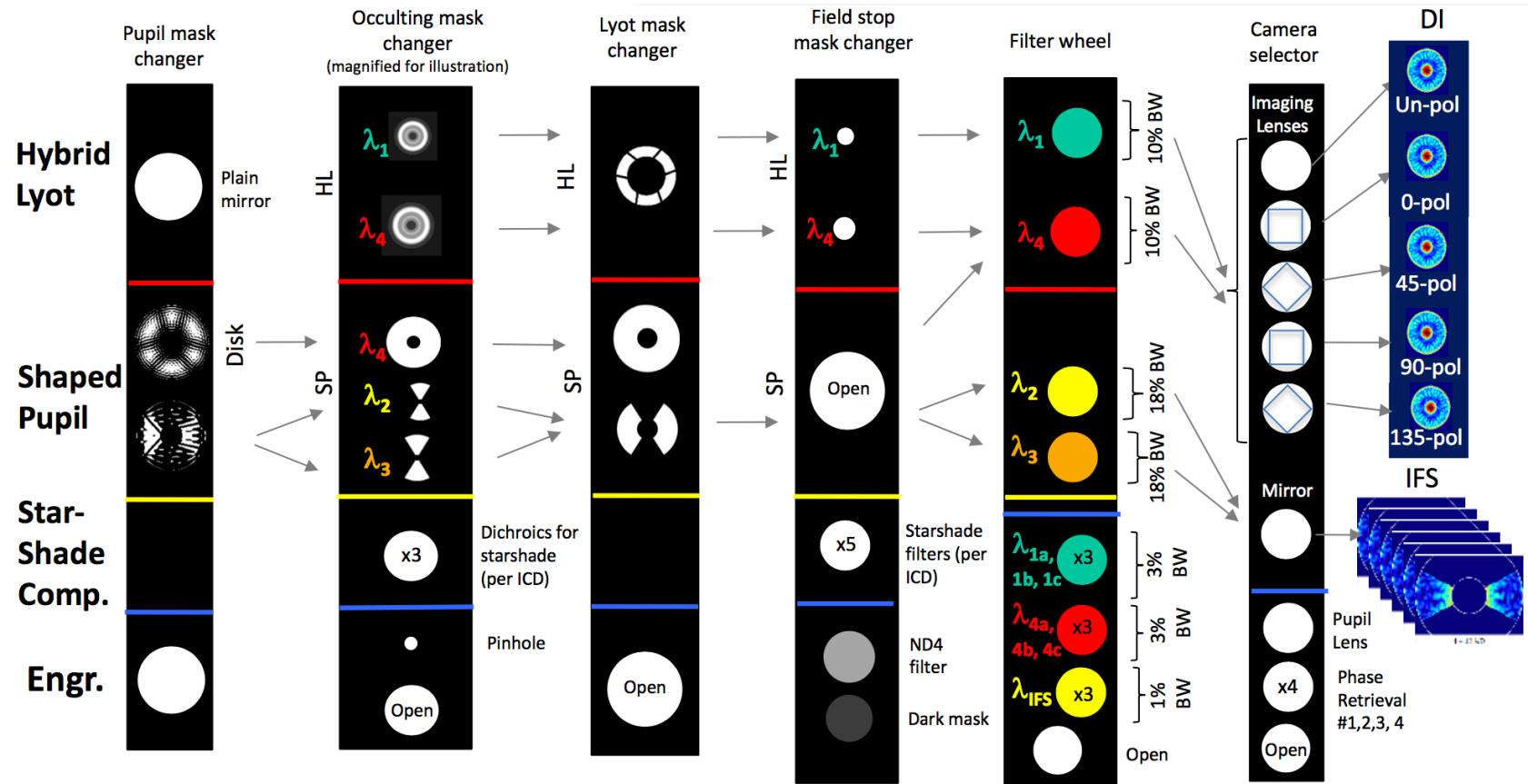
λ_1=575 nm, 10% (annular, 3-9 λ/D) λ_2=660 nm, 18% (bow-tie / IFS, 3-9 λ/D)
λ_3=760 nm, 18% (bow-tie / IFS, 3-9 λ/D) λ_4=825 nm, 10% (annular, 3-19 λ/D)

2019 **CGI** DATA CHALLENGE: **MODES**

1+1 Modes
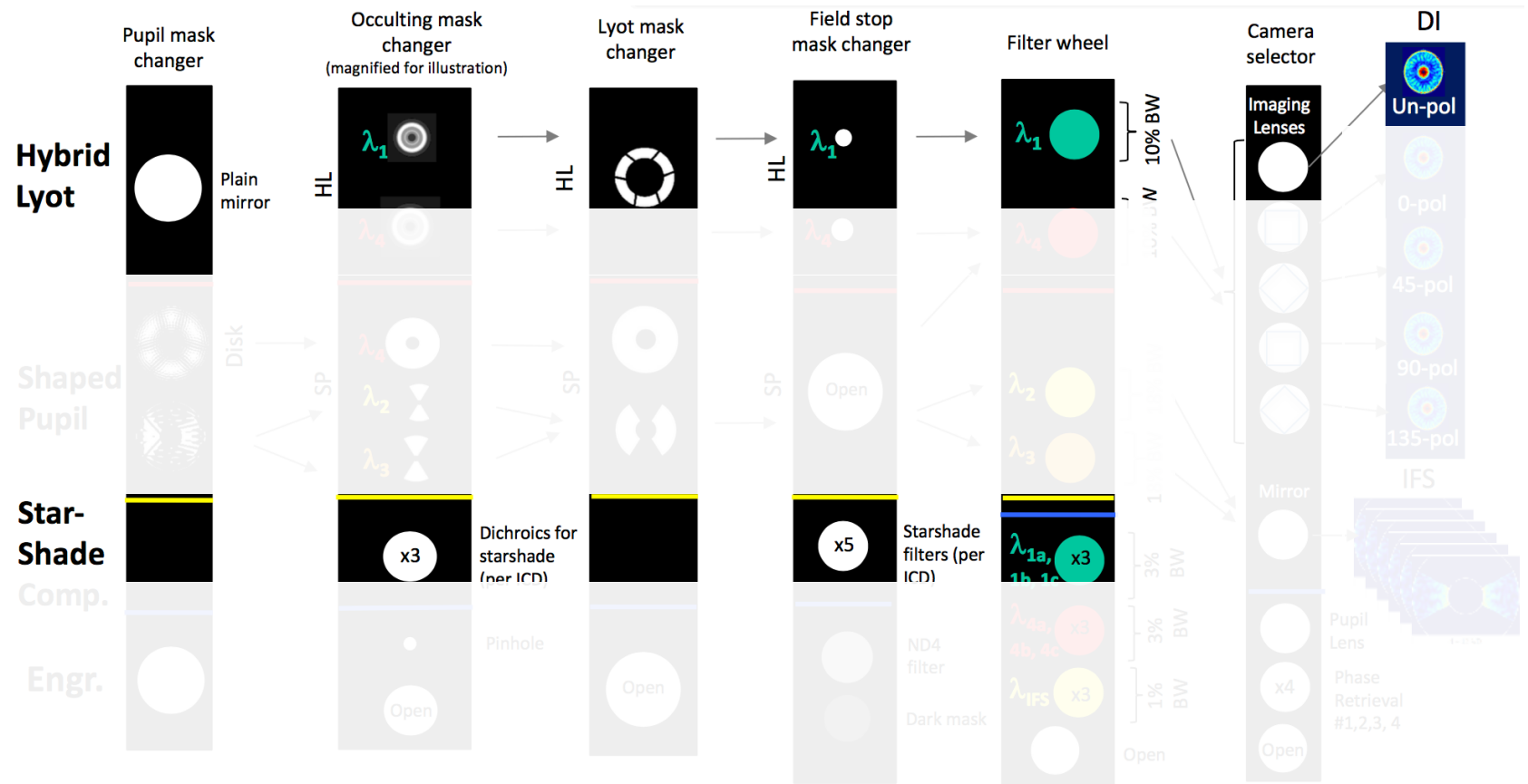
λ₁=575 nm, 10% (annular, 3-9 λ/D)   λ₂=660 nm, 18% (bow-tie / IFS, 3-9 λ/D)
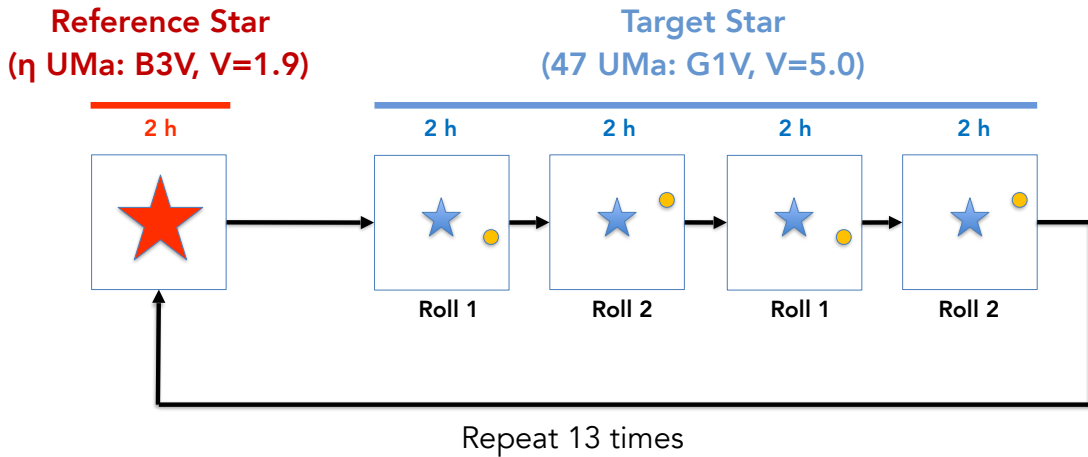λ₃=760 nm, 18% (bow-tie / IFS, 3-9 λ/D)   λ₄=825 nm, 10% (annular, 3-19 λ/D)

John Krist,
Robert Effinger,
Brian Kern,
Milan Mandic,
James McGuire,
Dwight Moody,
Patrick Morrissey,
Ilya Poberezhskiy,
A.J. Riggs,
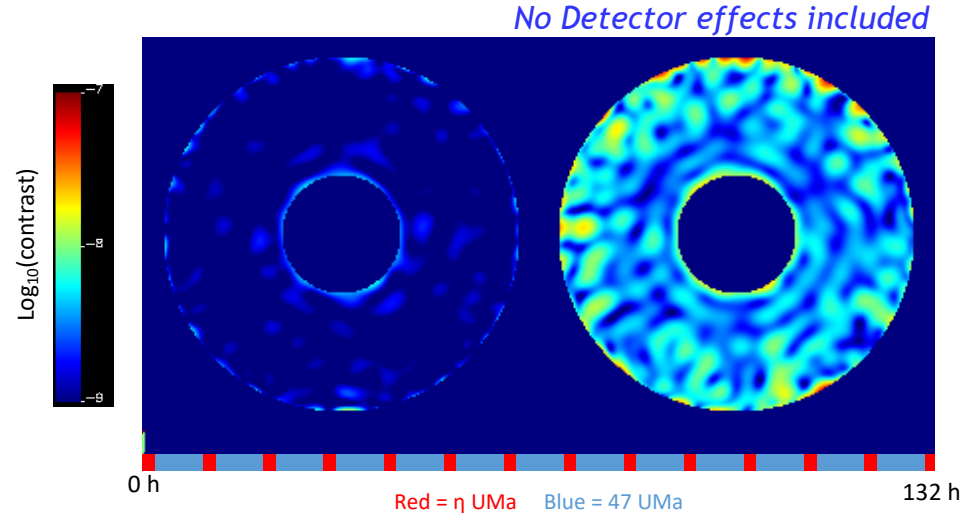Navtej Saini,
Erkin Sidick,
Hong Tang,
John Trauger

OBSERVING SCENARIO 6: **OS6**

RDI & roll Strategy

Reference Star
(η UMa: B3V, V=1.9)

Target Star
(47 UMa: G1V, V=5.0)

2 h   2 h   2 h   2 h   2 h
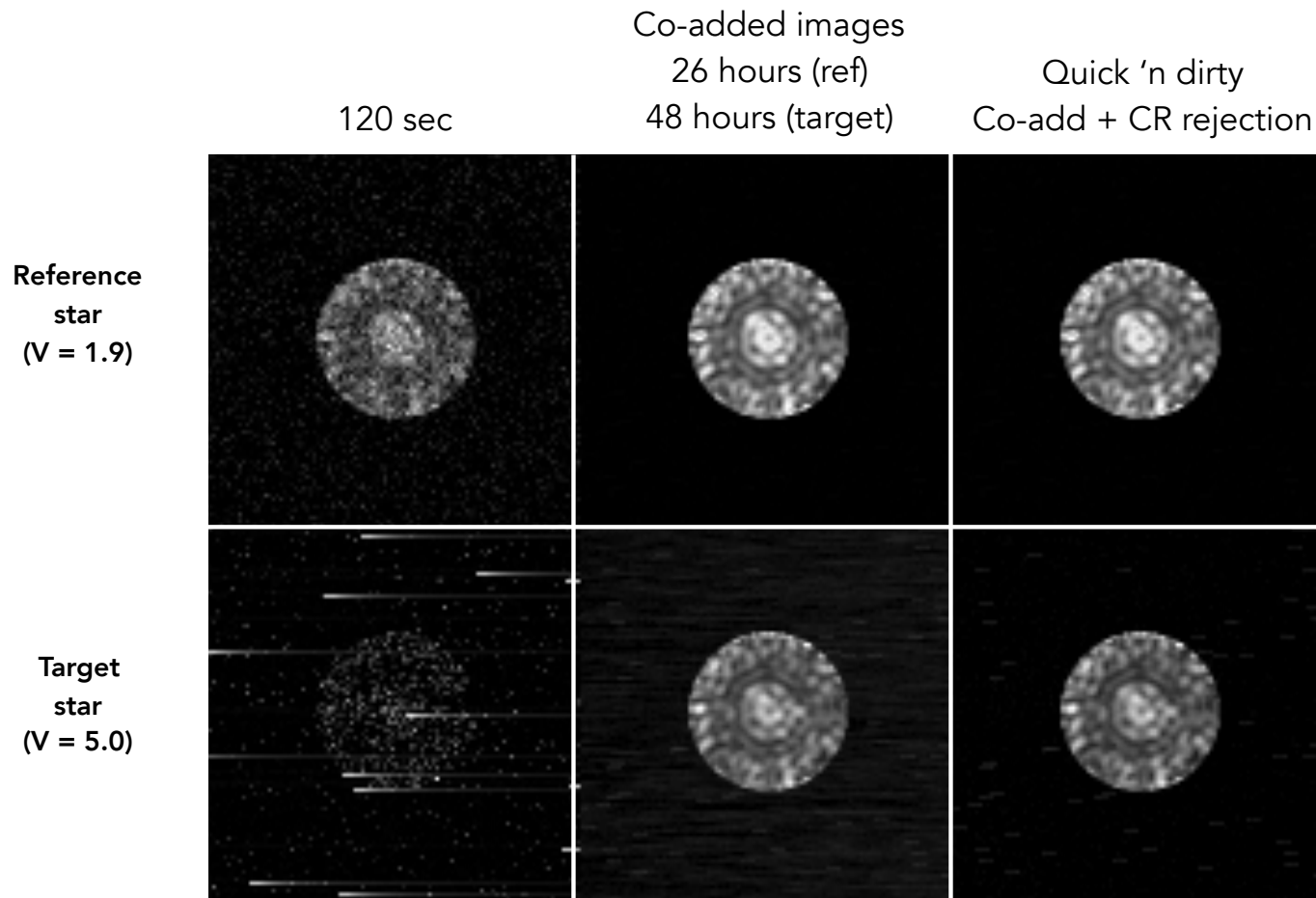
Roll 1   Roll 2   Roll 1   Roll 2
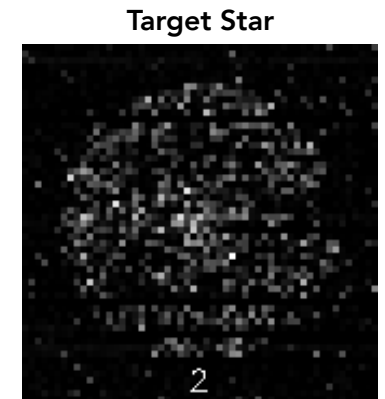
Repeat 13 times

Speckle Field Time Series

Static optical aberrations & polarization

Thermally-induced wavefront variations & LOWFS/C corrections

Thermally-induced pupil shear and DM variations

Variations in pointing & wavefront jitter due to changes in reaction wheel speeds over time

Application of optical Model Uncertainty Factors (MUFs)

Detector modeling (for HLC image stacks)

No Detector effects included

Log_{10}(contrast)

0 h   132 h

Red = η UMa   Blue = 47 UMa

8

EMCCD PHOTON COUNTING!!!

Co-added images
26 hours (ref)
48 hours (target)

120 sec

Quick 'n dirty
Co-add + CR rejection

Reference star (V = 1.9)

Target star (V = 5.0)

Ref = 3 sec/frame
Target = 30 sec/frame

Target Star

Minutes total exposure time
(1st 2 hours)

Note: Detector modeling software does not currently handle cosmic rays in short (3 sec) exposures properly

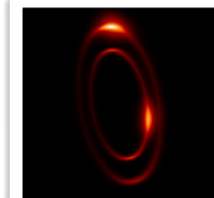# 2019 DATA CHALLENGE: BACKGROUND(S)

Extragalactic

Non-negligible contamination at flux ratios ~1e-9
Synthetic "Ultra Deep Field" cube (Roberge+2017)
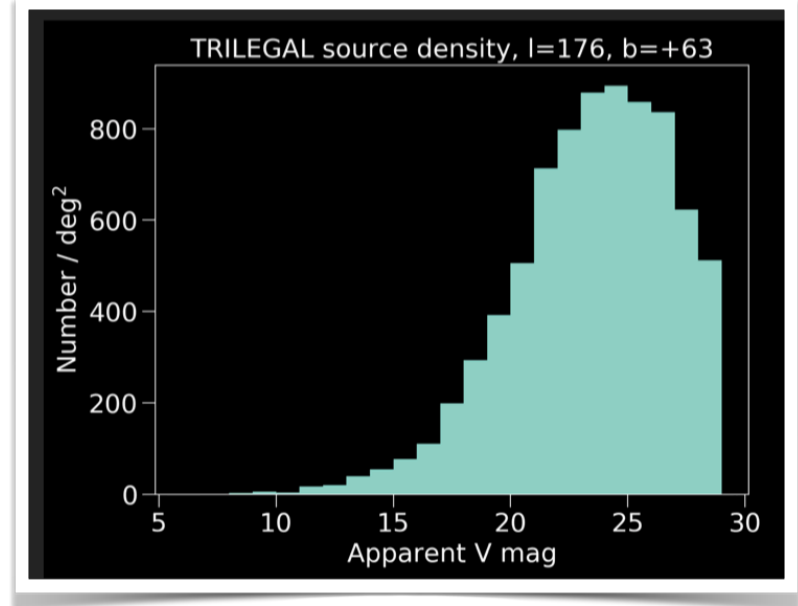Haystack Project
nasa.gov/projects/haystacks/haystacks.html
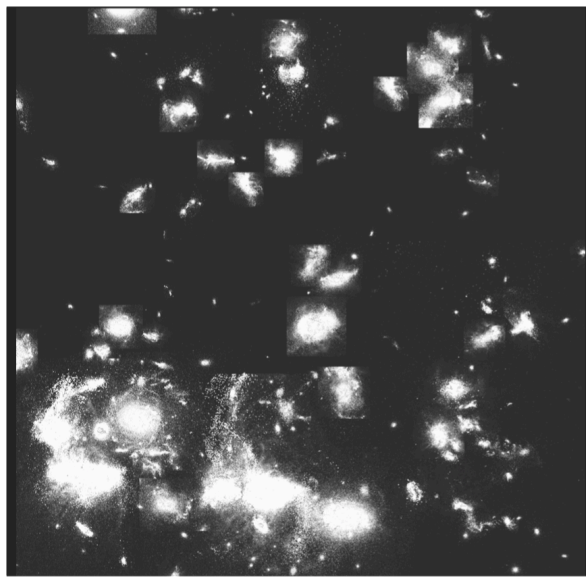
Exozodiacal Light

Zodipic
Inclined system
***

Galactic

Background star count density predicted by TRILEGAL Milky Way model peaks in the range V = 23-28.
A V = 5 science target star, 1e-9 flux ratio translates to V = 27.5
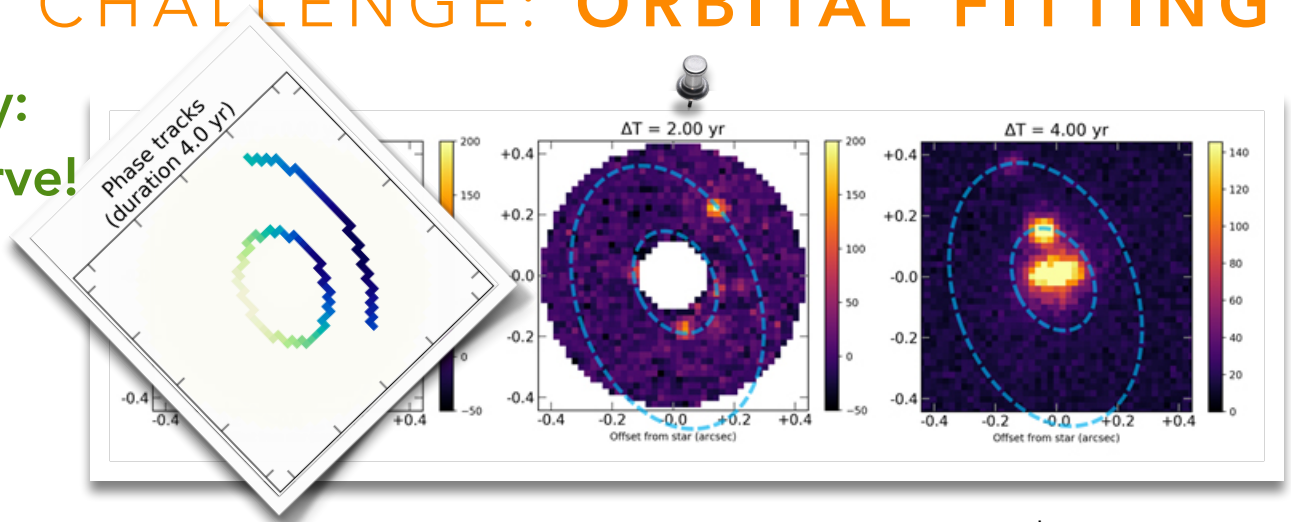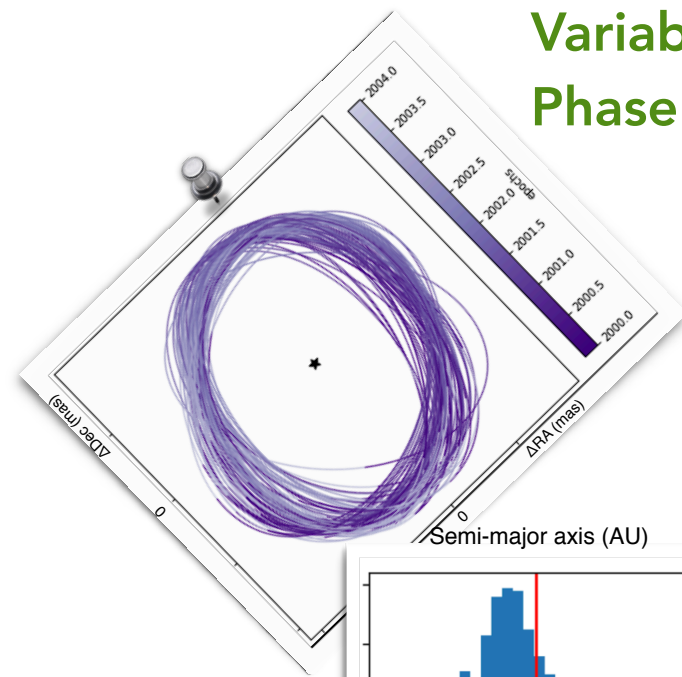
2019 DATA CHALLENGE: PARAMETERS

Data

	PIX SCALE	FILTER BANDPASS	CENTER WAVELENGTH	STAR LIGHT SUPPRESSION	WORKING ANGLE
HLC	21.08 mas	546 - 604 nm	575	360°	3-9λ/D 150 to 500 mas
SS		425 - 552 nm	488.5		independant of λ 72 to > 1000 mas

Stars

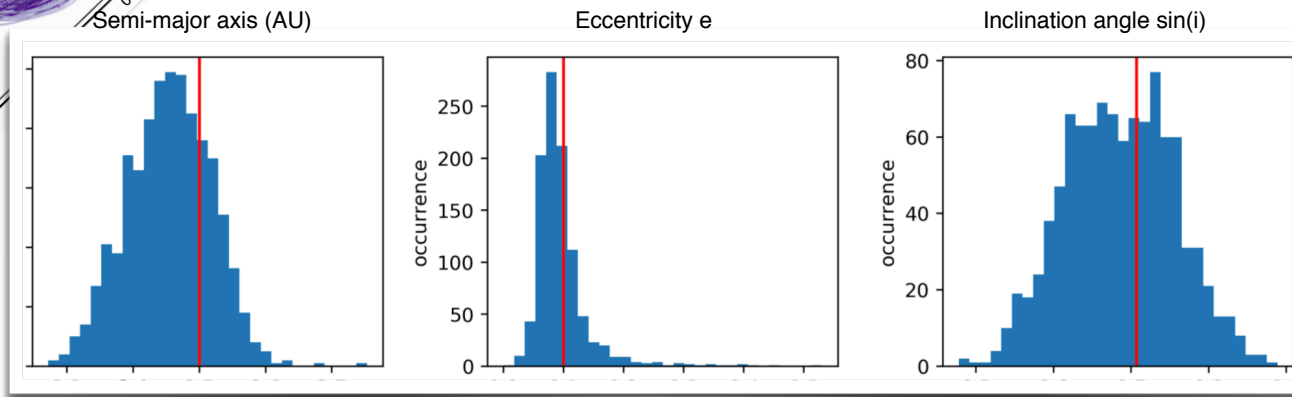|	VMAG	SPECTRAL TYPE	RA	DEC	PROPER MOTION	DISTANCE	PARALLAX
47 UMA	5.04	G0V	10 59 27.9738	+40 25 48.922	-317.642 mas/yr 55.014 mas/yr	13.8 pc	2.4528 mas
REF	1.86	B3V	13 47 32.4377	+49 18 47.760			

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2019 DATA CHALLENGE: **ORBITAL FITTING**

**Variability:
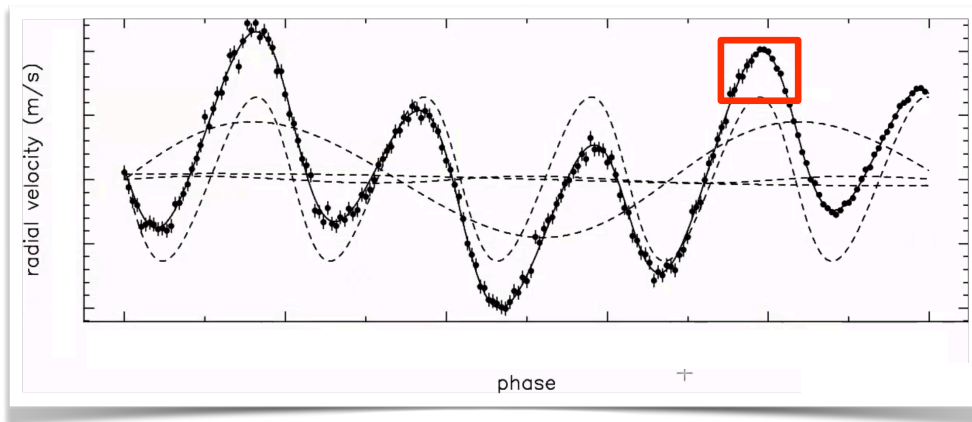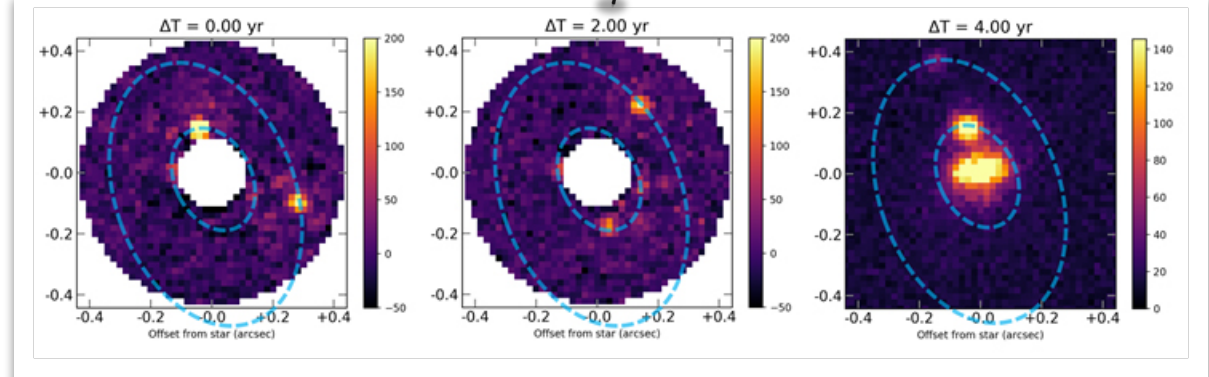Phase curve!**

Neil Zimmermann
Sergi Hildebrandt

Junellie Gonzalez-Quiles
Using Orbitize/OFTI
(Blunt 2017)
Preliminary

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2019 DATA CHALLENGE: RADIAL VELOCITY

**With only 2 or 3 imaging epochs
Can one constraint orbital parameters
using prior RV knowledge,
the phase function?**

Stephen Kane
Zhexing Li
(RadVel)

Neil Zimmermann
Sergi Hildebrandt (next talk on SS)

2006 - 2020 ~1 m/s accuracy (e.g. Keck)
2020 - 2014 ~0.3 m/s accuracy (e.g. NEID)

* Cross-instrument calibrations ok

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2019 DATA CHALLENGE: TIMELINE

✔

Hackathon
@STScI
March 18-19

→

Hackathon
@IPAC
June 24-25

Next week!

→

Kick-Off

In the Spirit of
LYOT 2019 東京
TOKYO

October 20

→

Deadline
December 20

2019

→

Results

~March

→

**Prizes/Talks
Exoplanets III (?)
July 27-31**

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2019 DATA CHALLENGE: ORGANIZATION

Website / videos to present our material, events, links to packages

Slack channel to answer questions, help assemble teams

Outerspace to give more technical information, write down telecon minutes
https://outerspace.stsci.edu/display/CGI/CGI+Data+Challenges

Box folders to make the data available

Hackathons: next week and full DC day on October 20th in Tokyo (engage local/asian community)

TBD: incentives, metrics, prizes, publication policy

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