Survey of Transit Surveys: From *Kepler* & K2 to TESS, CHEOPS, & PLATO

Courtney Dressing
NASA Sagan Fellow at Caltech

Sagan Exoplanet Summer Workshop 2016
July 22, 2016


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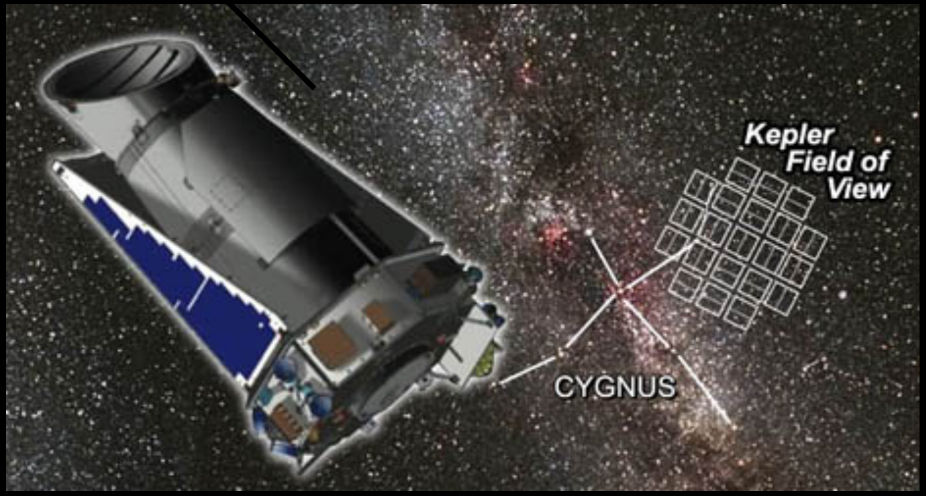
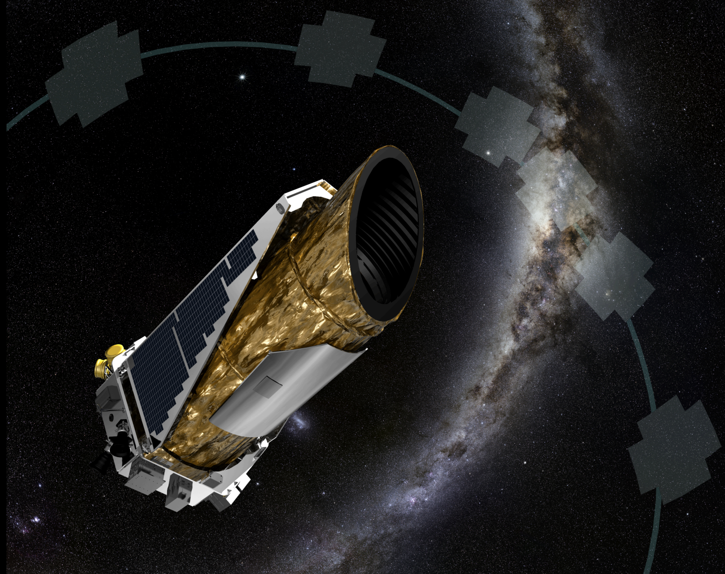
Kepler

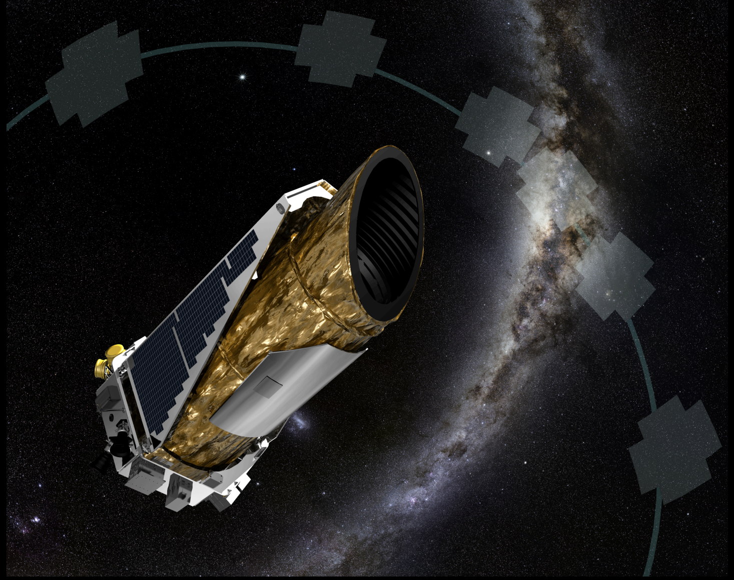




K2

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Kepler



K2

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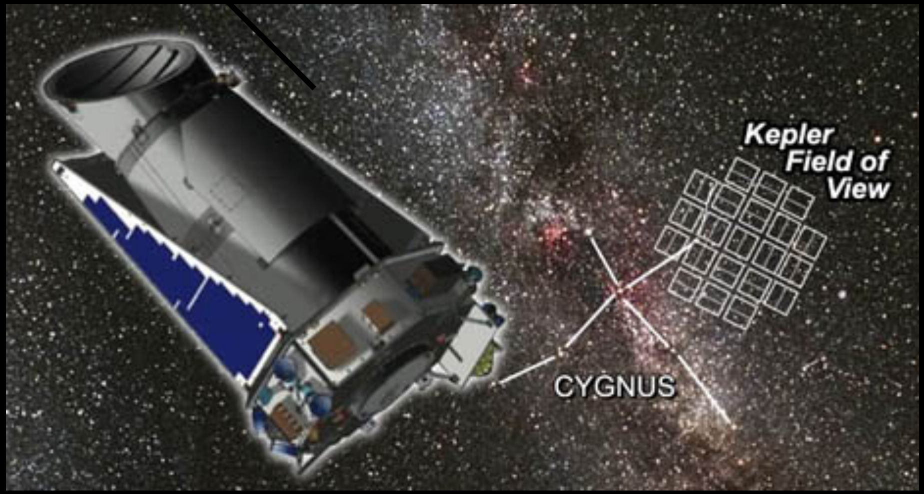
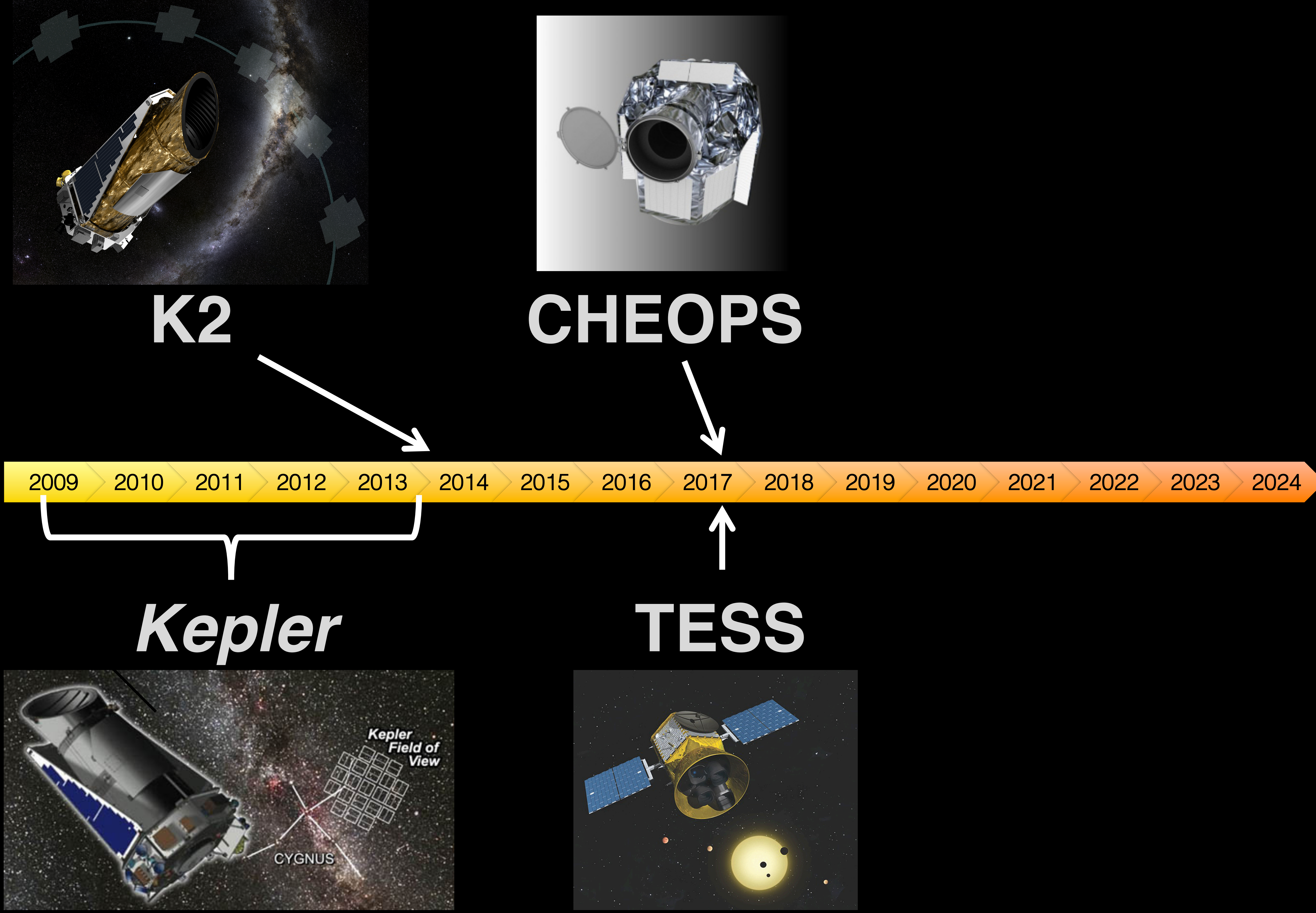
Kepler

TESS

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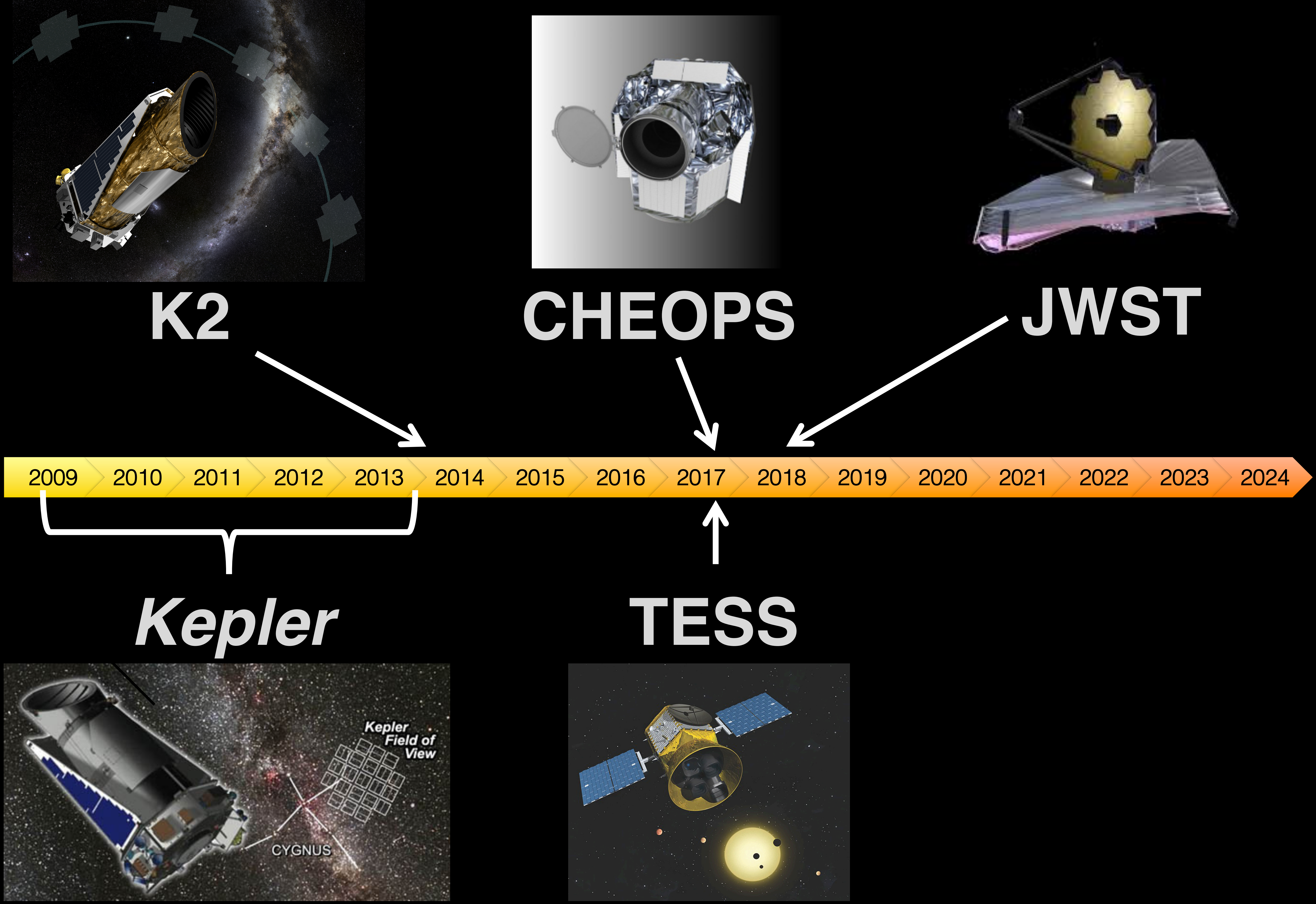
TESS
Kepler Field of View
CYGNUS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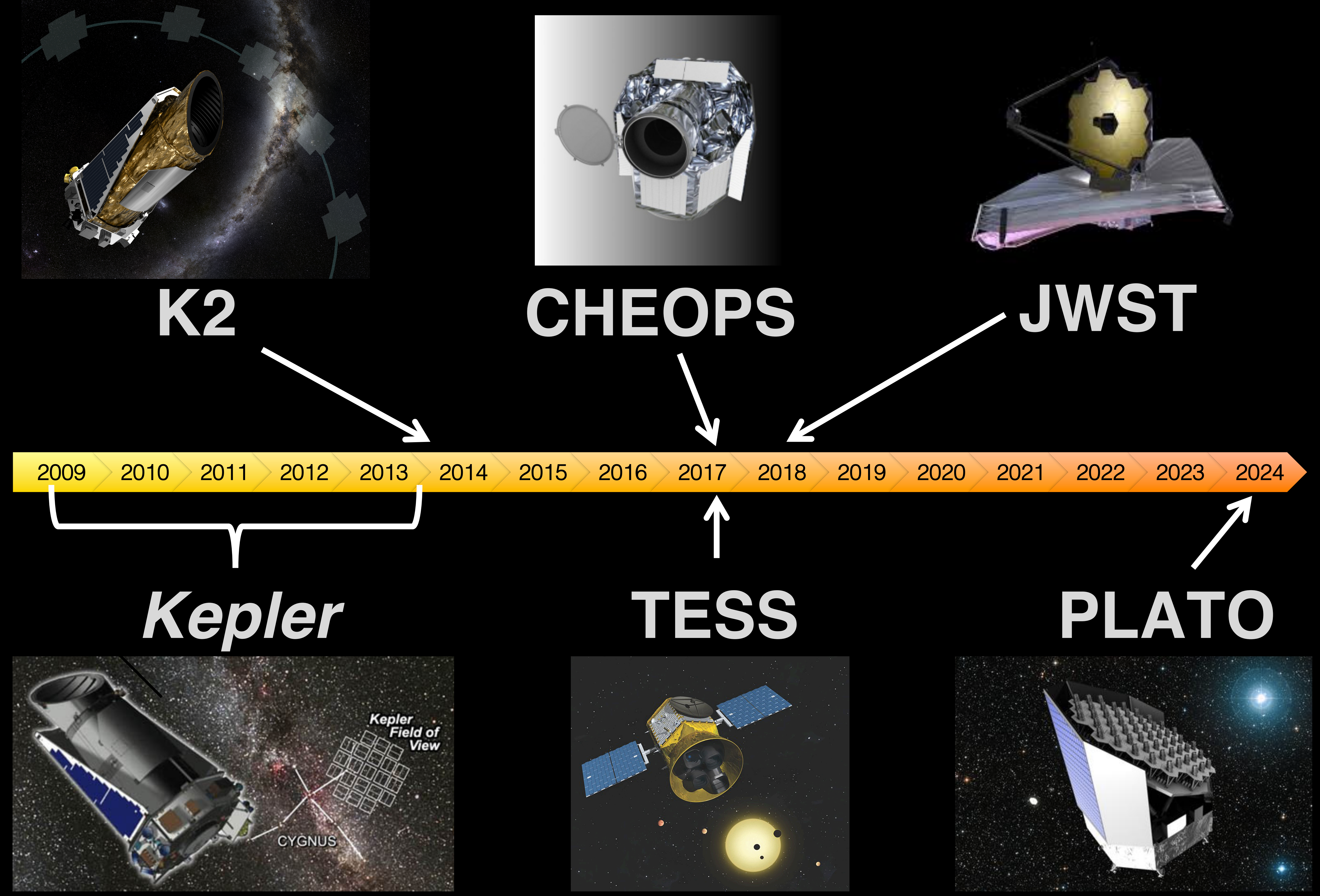
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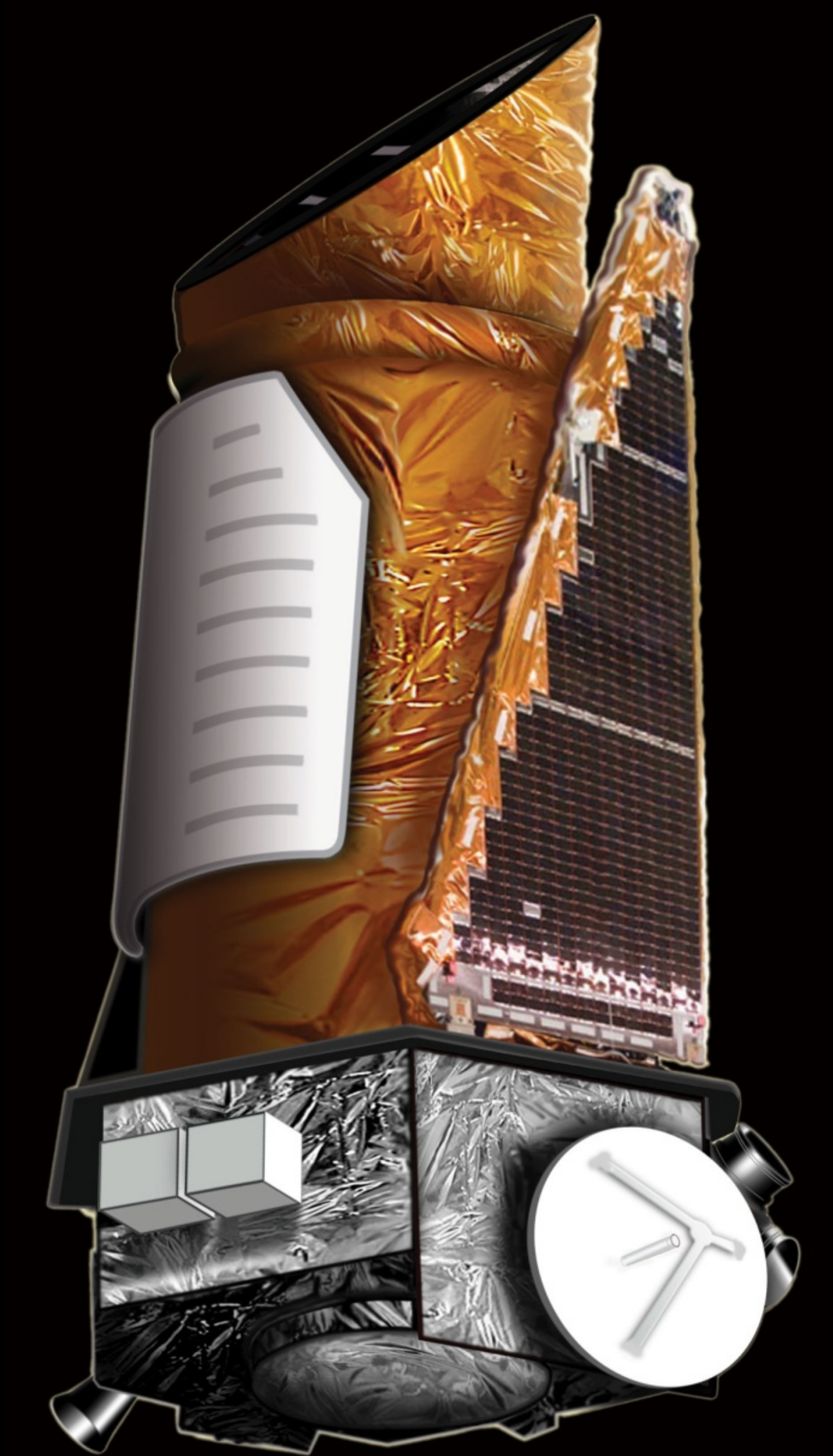
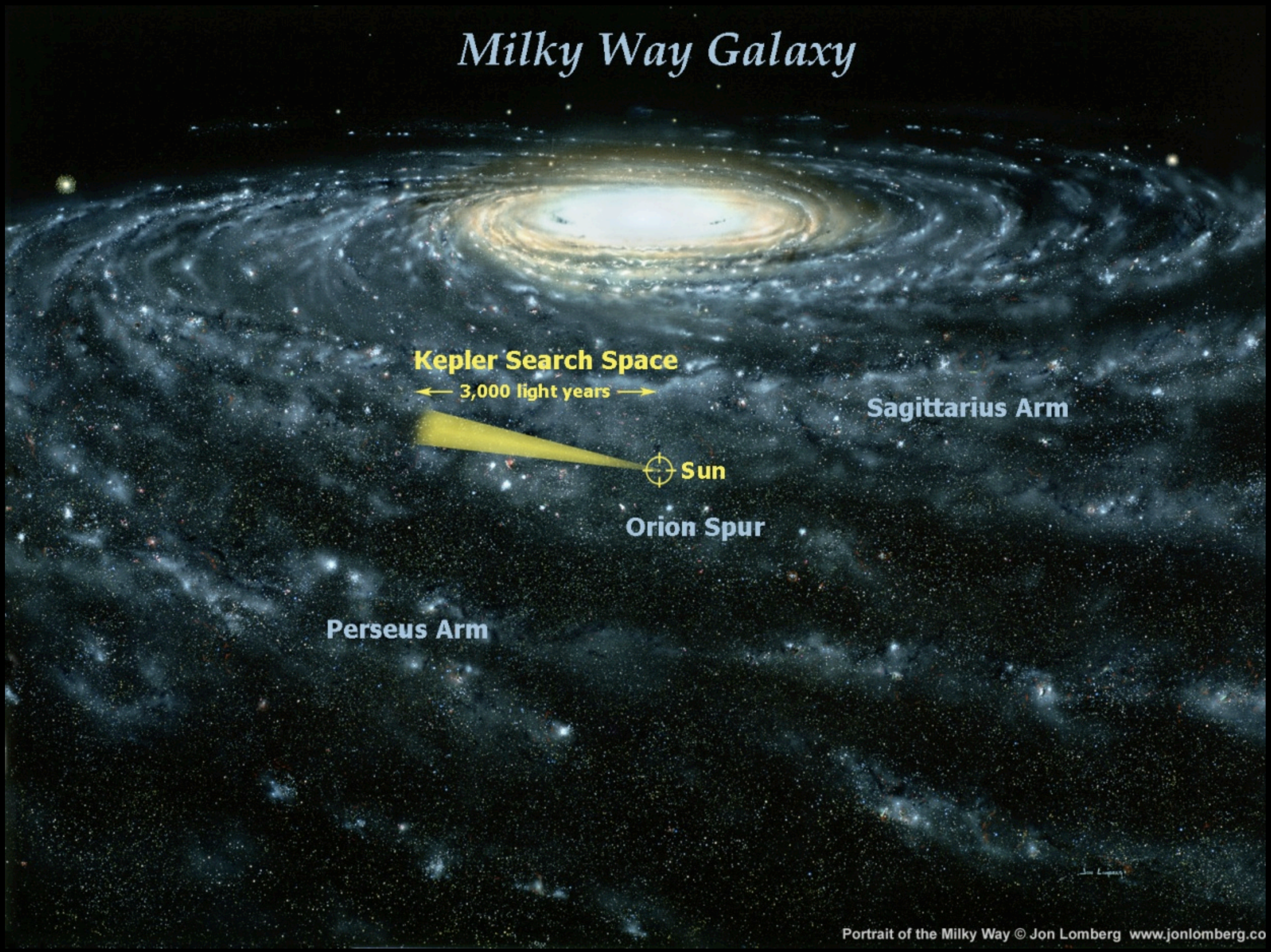
The *Kepler* Mission: 2009 - 2013





NASA/*Kepler* mission

The *Kepler* Mission: 2009 - 2013

NASA/*Kepler* mission

Kepler is dead.

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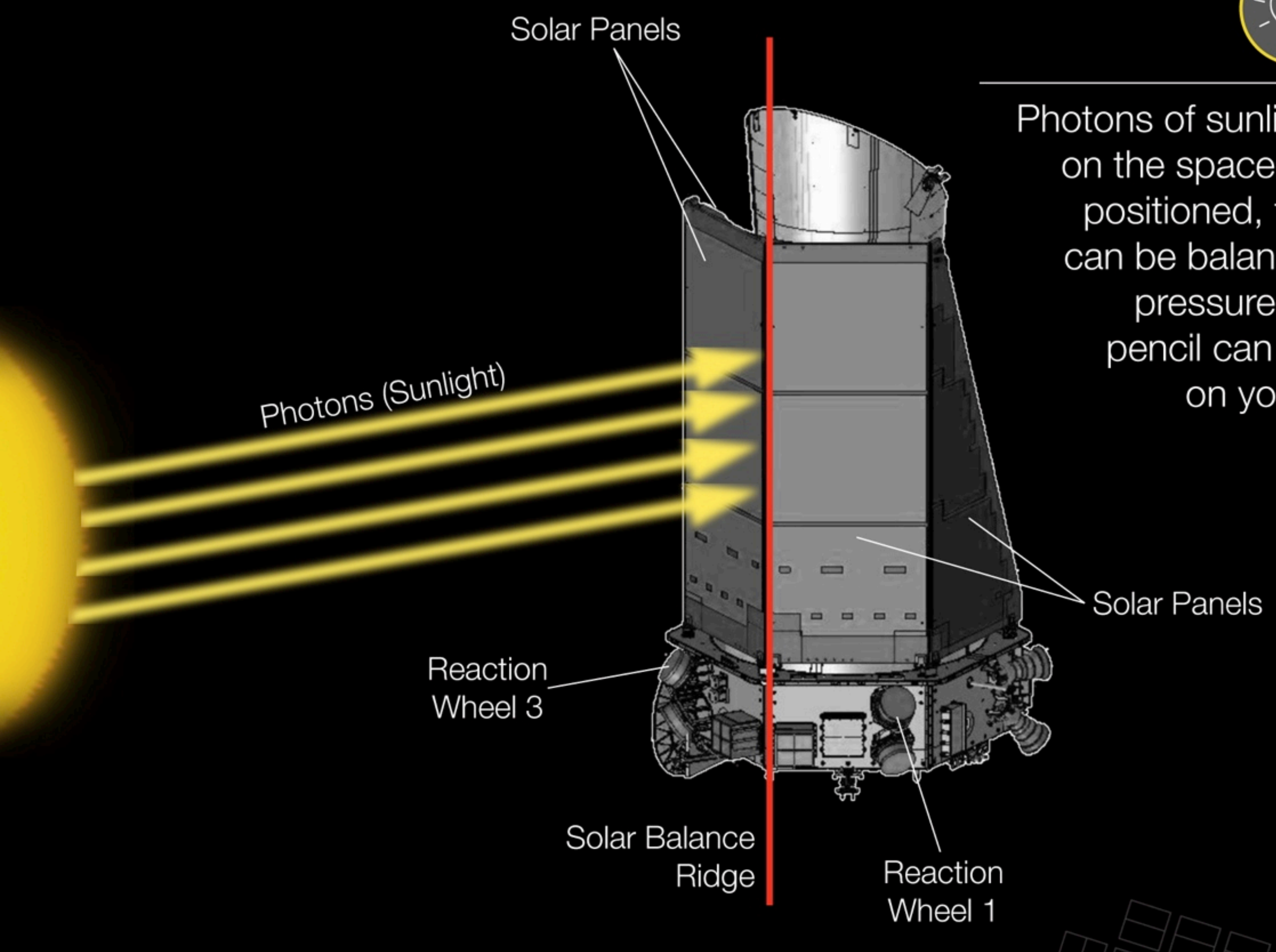
Long live K2?

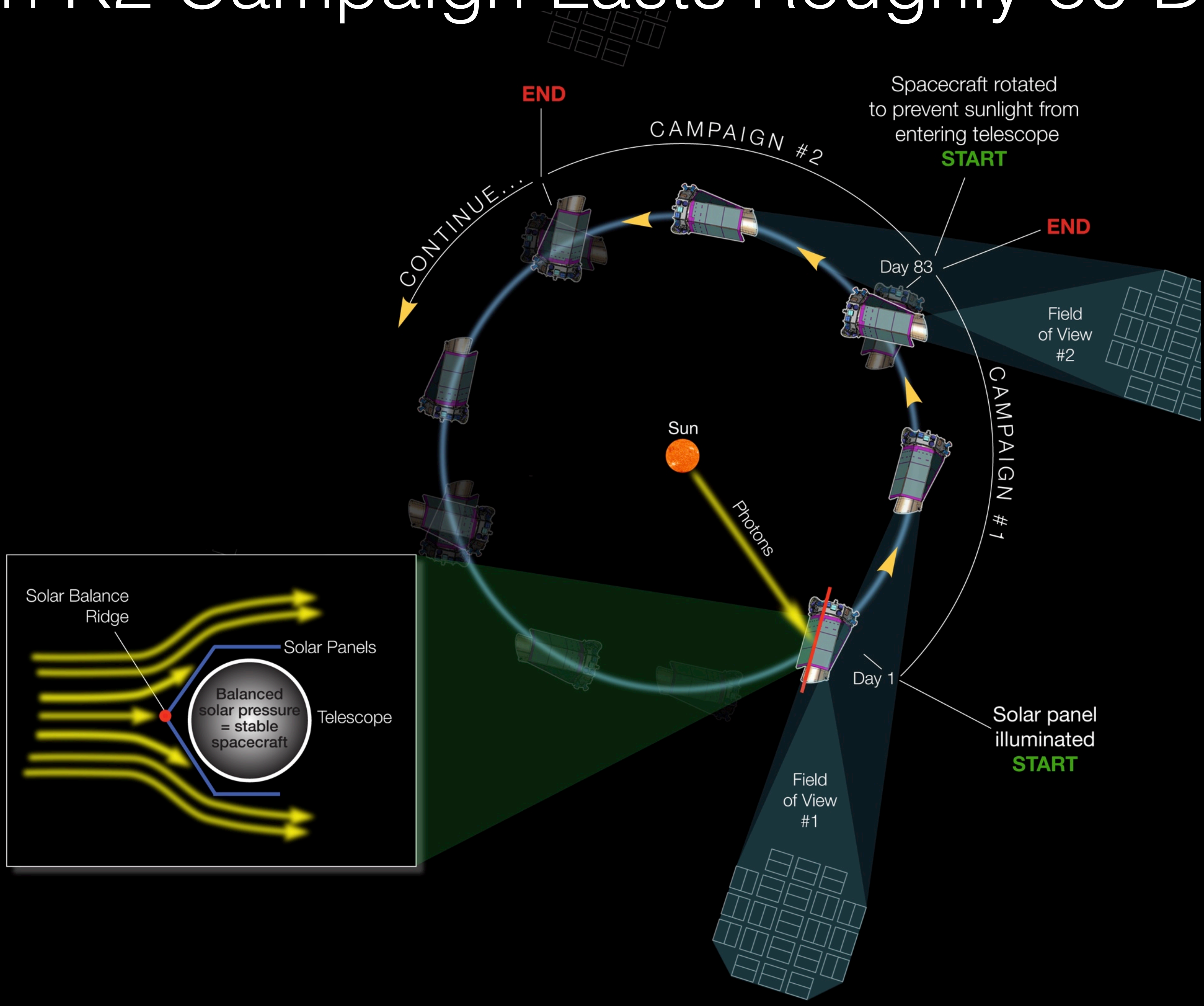
The K2 Mission is a Balancing Act



Photons of sunlight exert pressure on the spacecraft. If properly positioned, the spacecraft can be balanced against the pressure much as a pencil can be balanced on your finger.

http://www.nasa.gov/kepler/keplers-second-light-how-k2-will-work

Each K2 Campaign Lasts Roughly 80 Days



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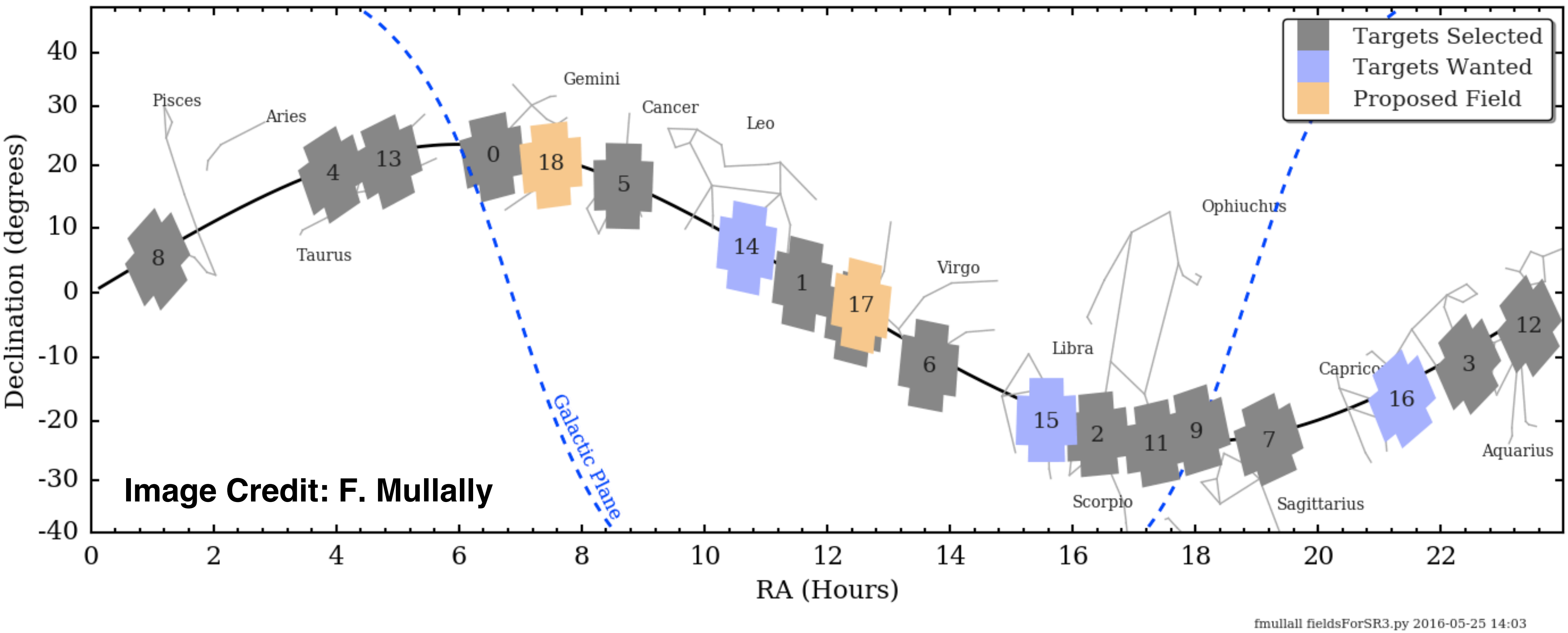
Where is K2 Looking?



http://keplerscience.arc.nasa.gov/k2-ddt.html

http:/keplerscience.arc.nasa.gov/k2-proposing-targets.html#solicitations/

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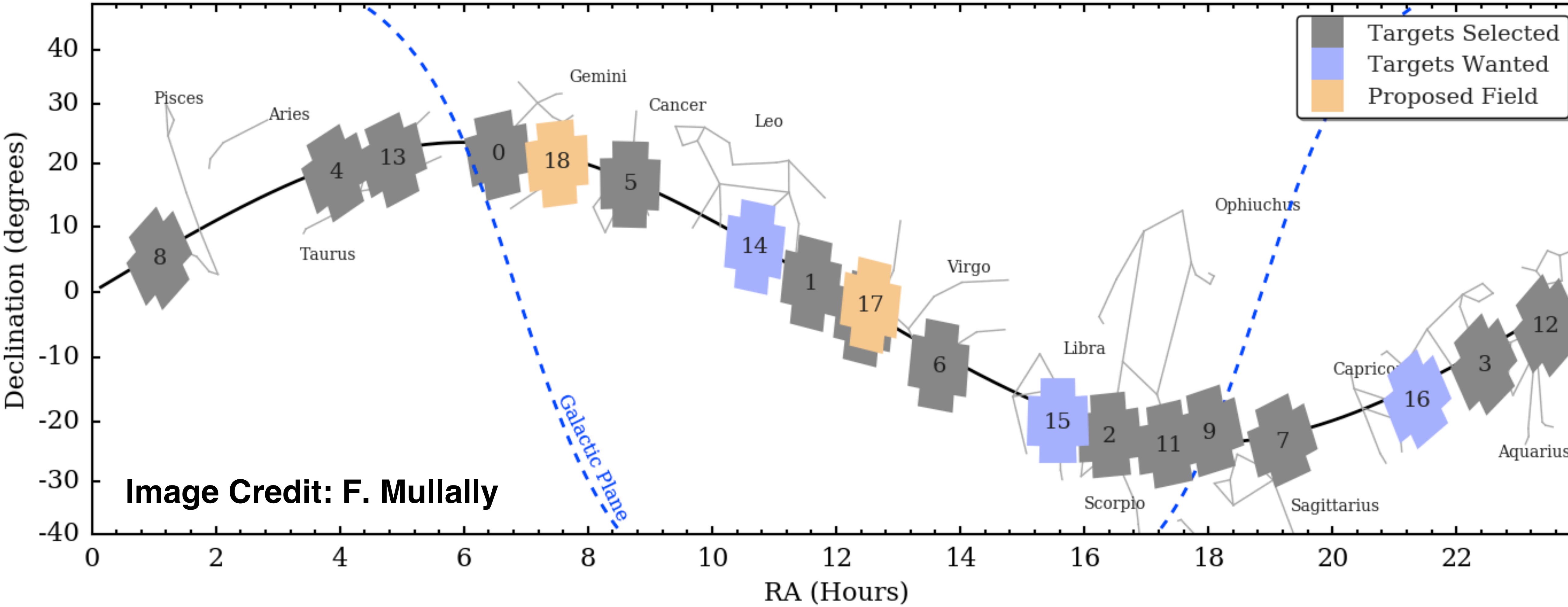

Send your target recommendations!

Opportunity	Deadline
Campaign 12 Director's Discretionary Time:	August 18, 2016
K2 GO Cycle 5 (Campaigns 14 - 16) Step 1:	September 23, 2016
K2 GO Cycle 5 (Campaigns 14 - 16) Step 2:	November 4, 2016
Campaign 13 Director's Discretionary Time:	November 10, 2016

http://keplerscience.arc.nasa.gov/k2-ddt.html http:/keplerscience.arc.nasa.gov/k2-proposing-targets.html#solicitations/

How does K2 differ from the prime *Kepler* mission?

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Baseline	4 years	80 days

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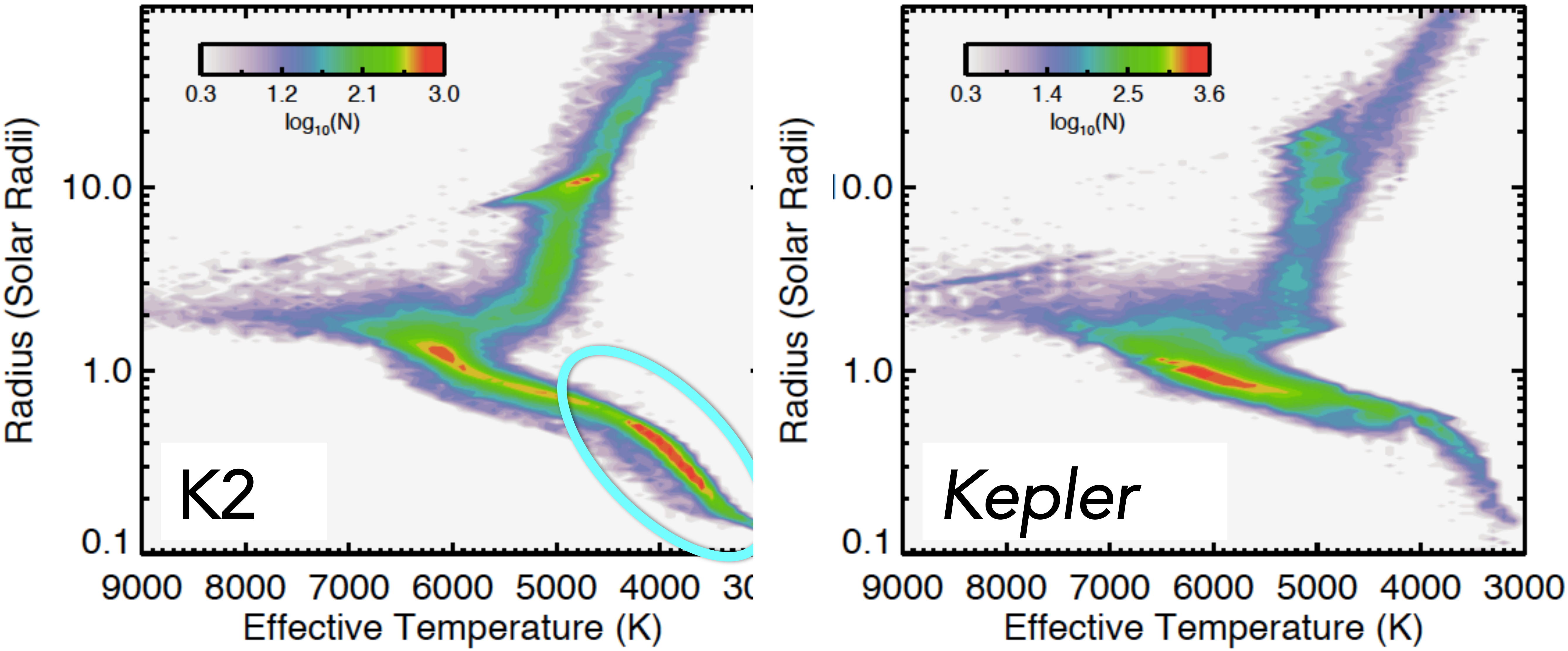
Scientific Emphasis	Constrain the frequency of Earth-like planets orbiting Sun-like Stars	Exoplanets (transits & microlensing), stellar physics, extragalactic astronomy, etc.

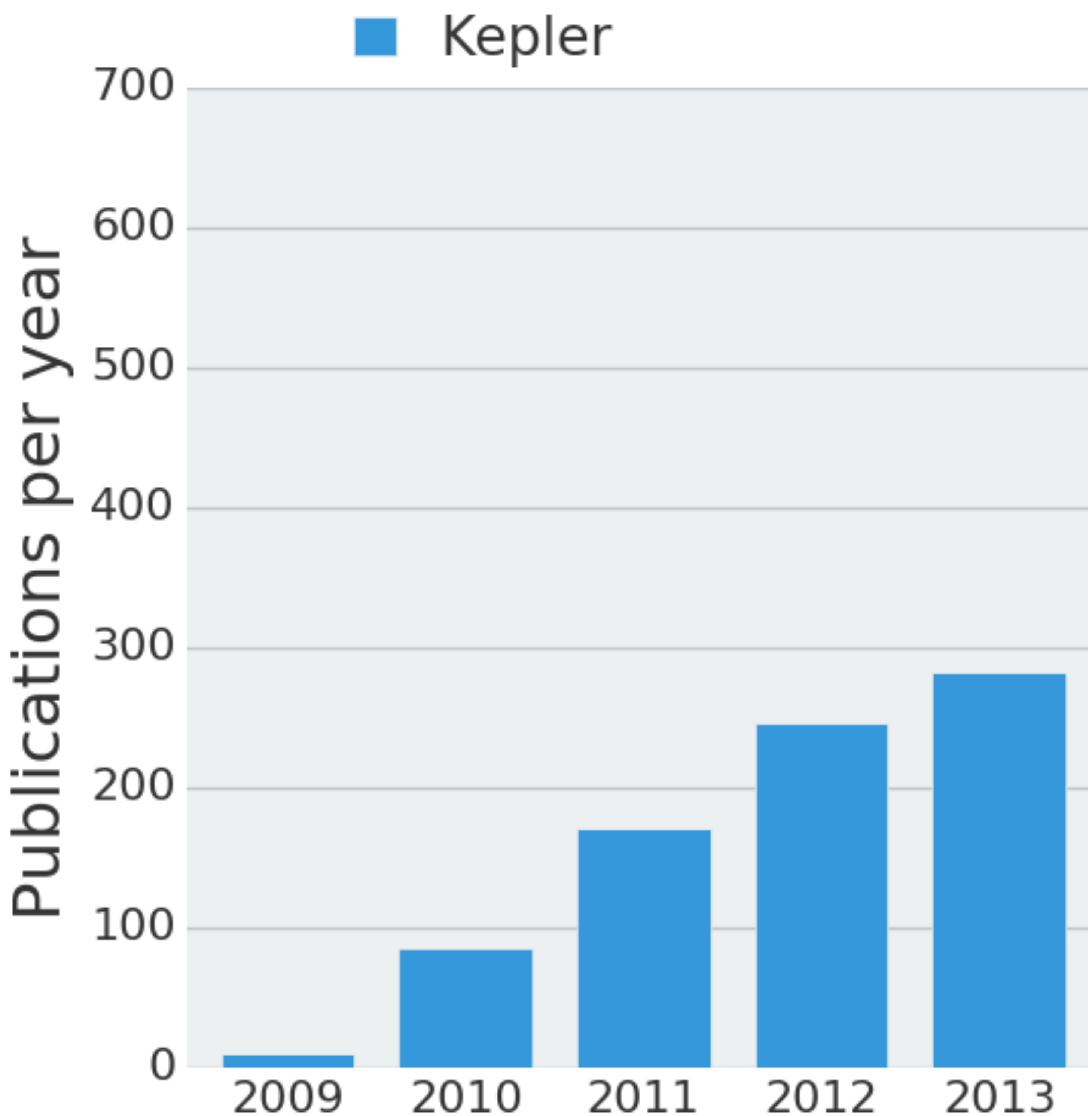
K2 is Observing Many Small Stars



41% of selected K2 targets are K and M dwarfs

Huber et al. 2016, ApJS, 224, 2

K2 Papers are Plentiful



http://keplerscience.arc.nasa.gov/publications.html

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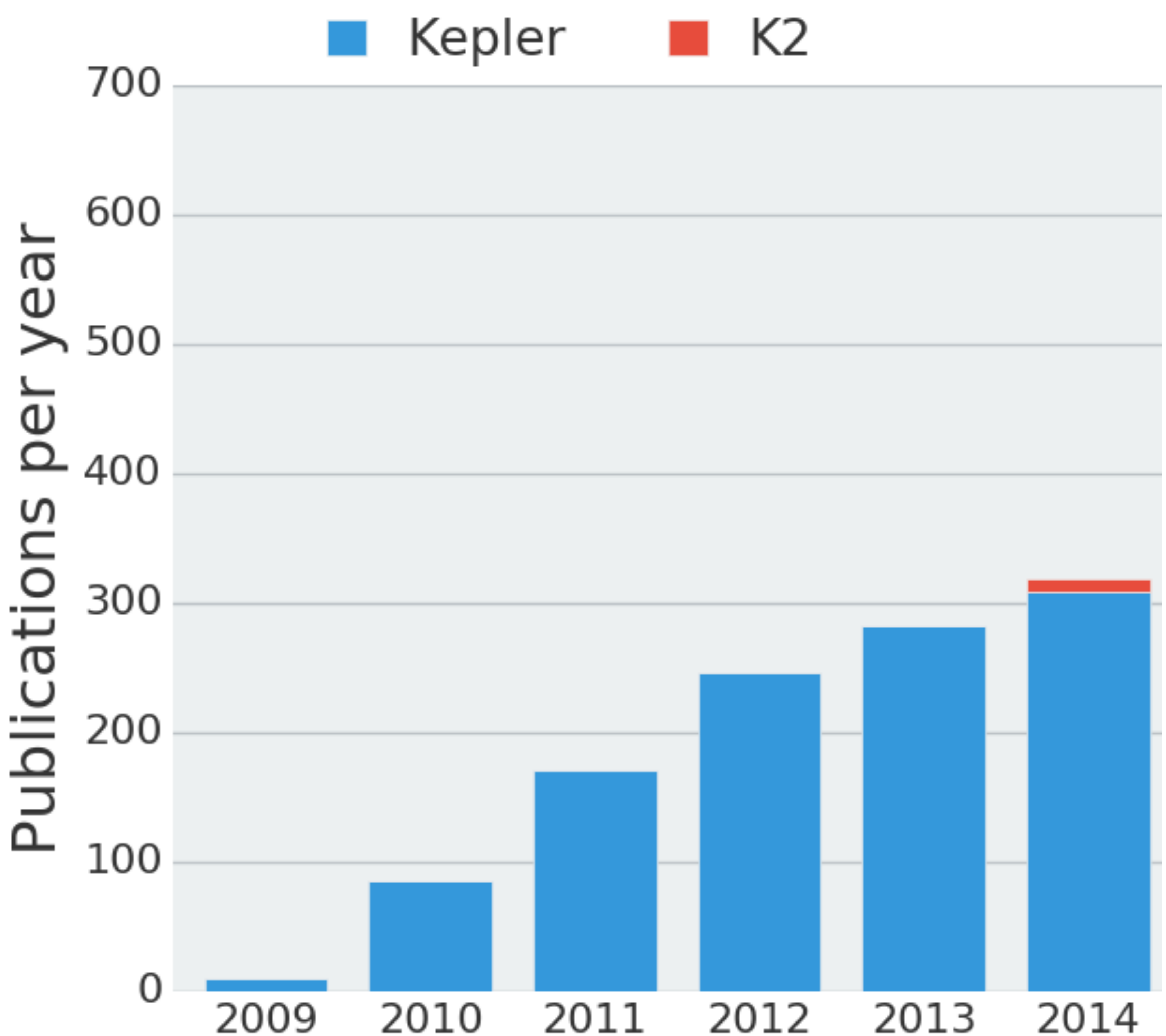

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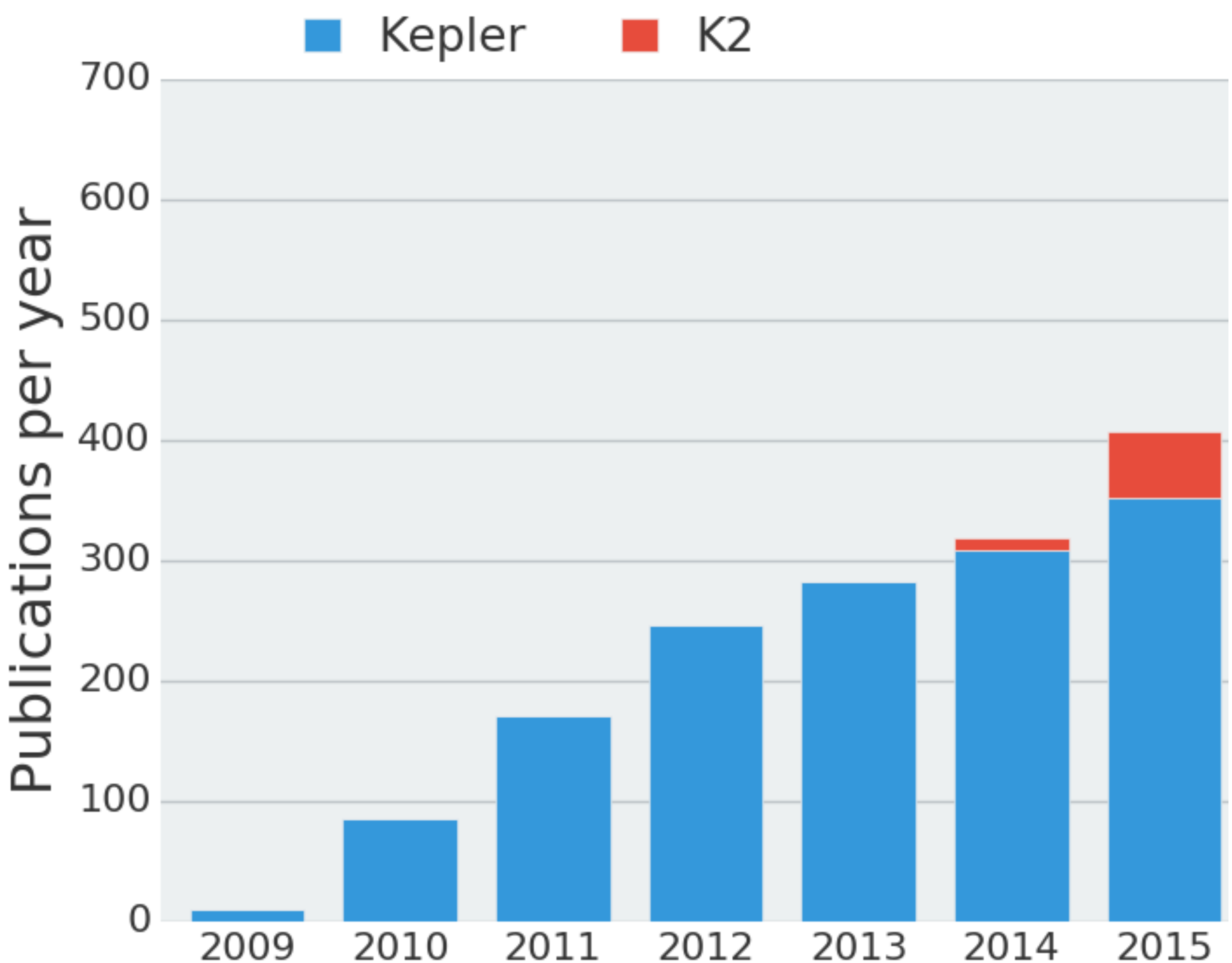

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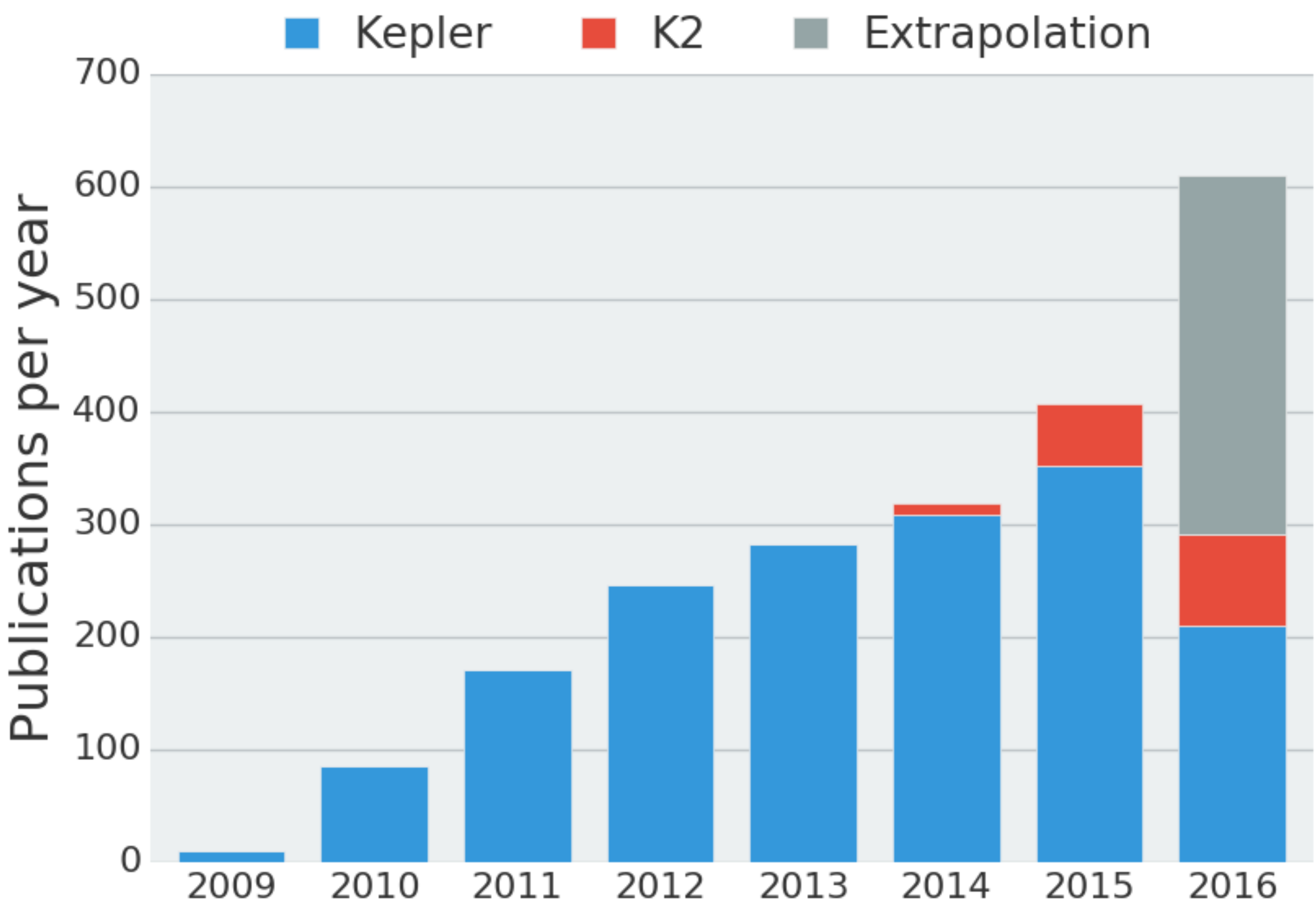

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A few highlights from K2

Close-in Planets Can be Tidally Disrupted

THE K2-ESPRINT PROJECT. I. DISCOVERY OF THE DISINTEGRATING ROCKY PLANET K2-22b WITH A COMETARY HEAD AND LEADING TAIL

R. Sanchis-Ojeda[1,25], S. Rappaport[2], E. Pallè[3,4], L. Delrez[5], J. DeVore[6], D. Gandolfi[7,8], A. Fukui[9], I. Ribas[10],

Sanchis-Ojeda+ 2015, ApJ, 812, 112

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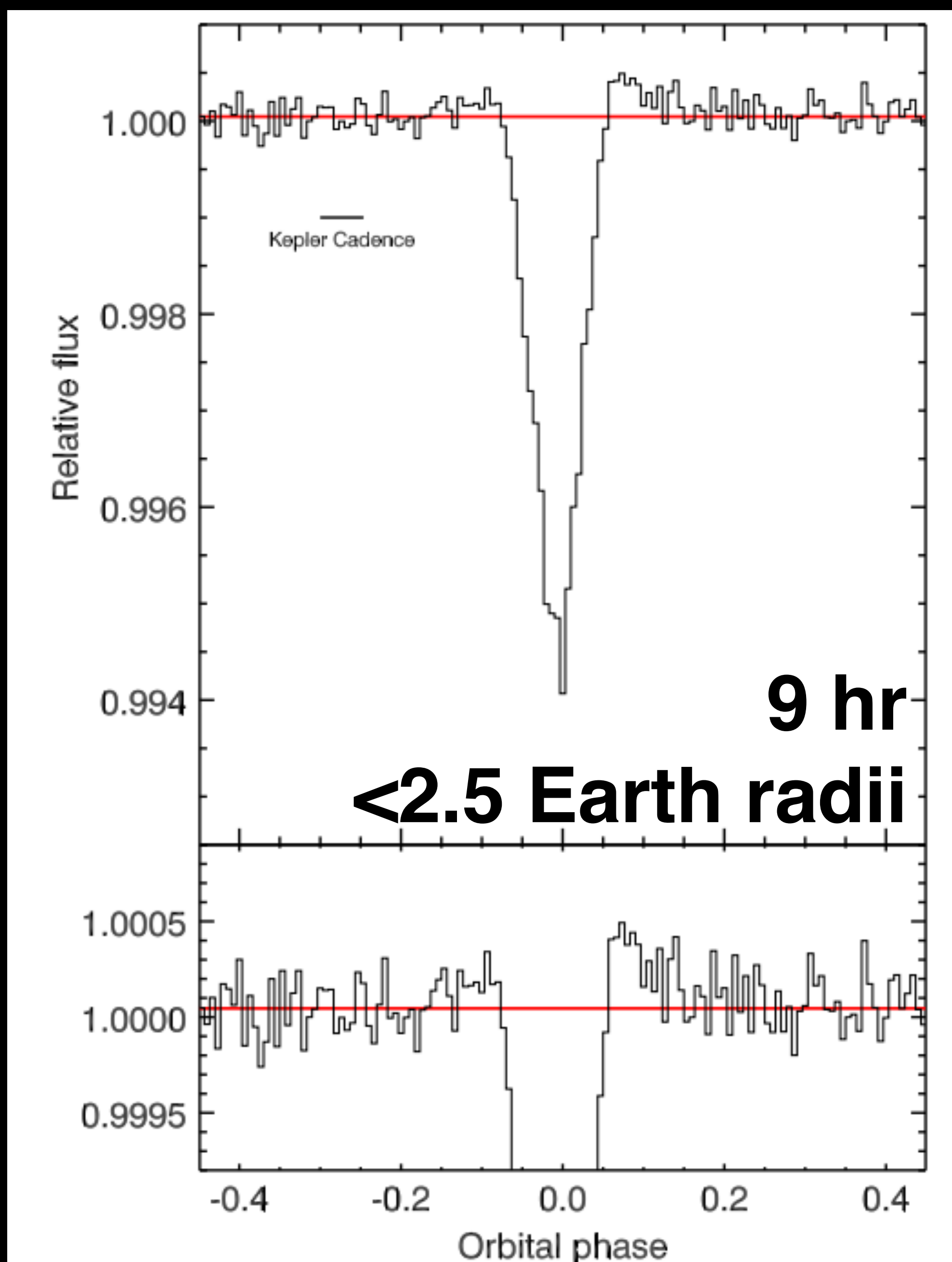

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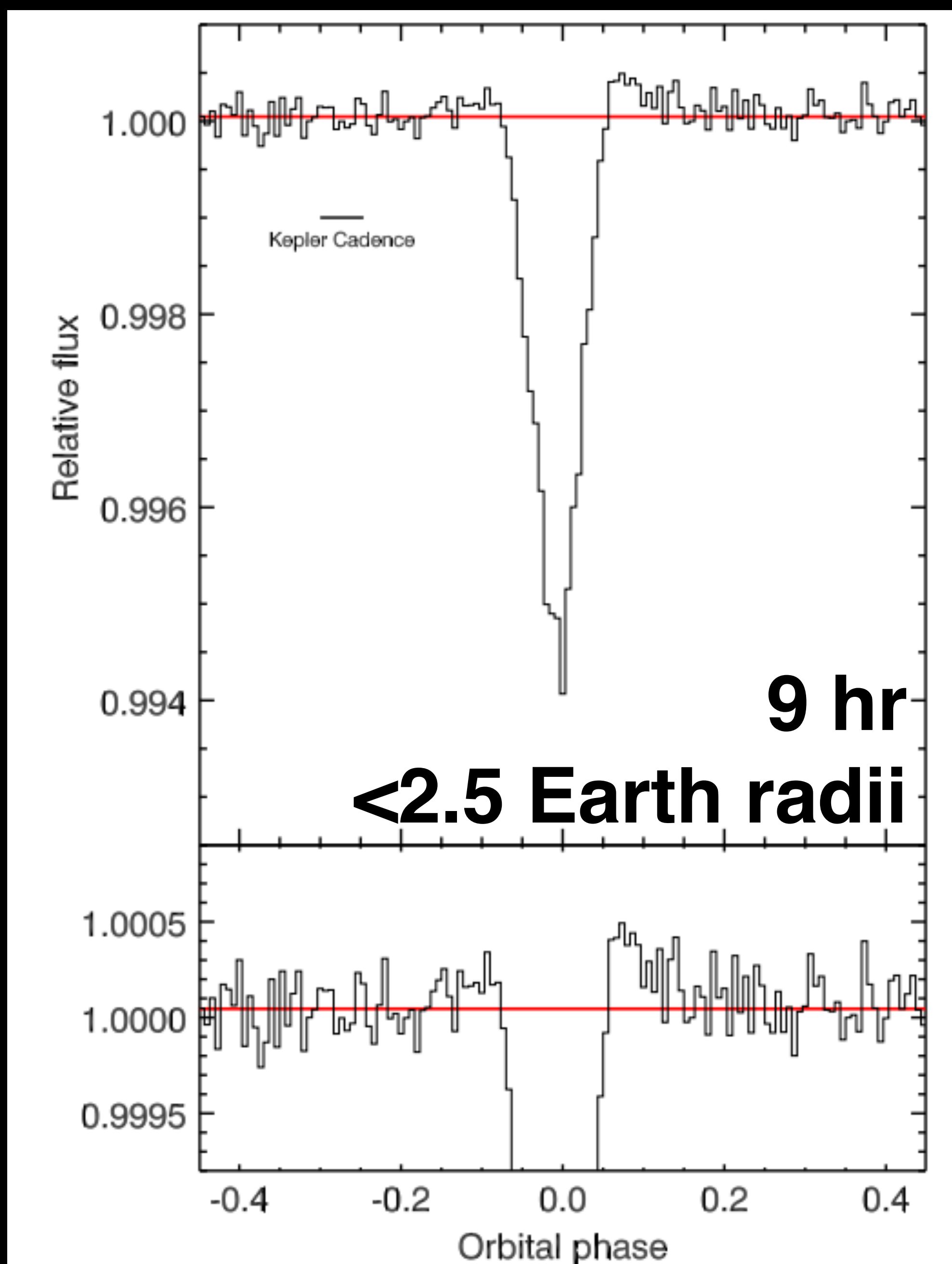

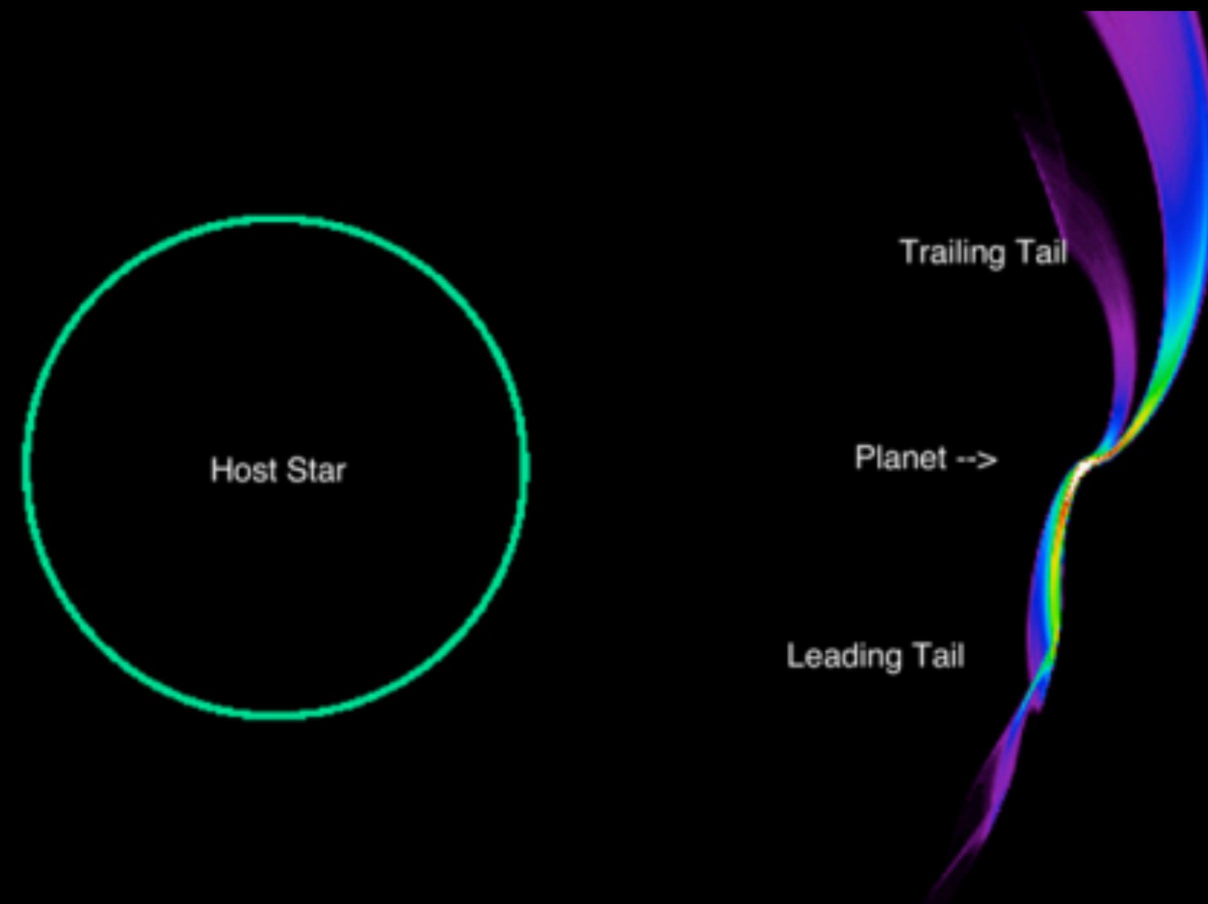

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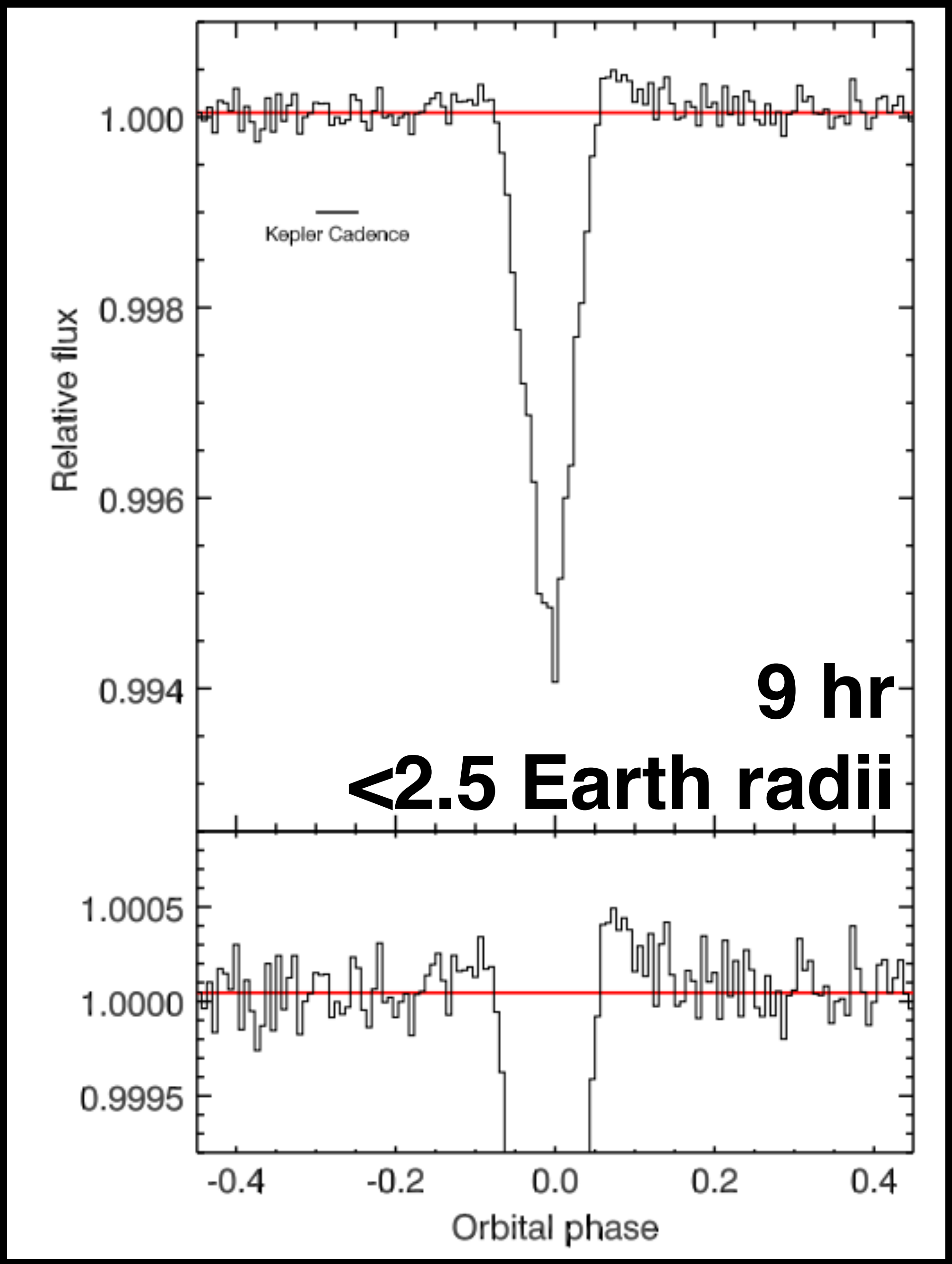

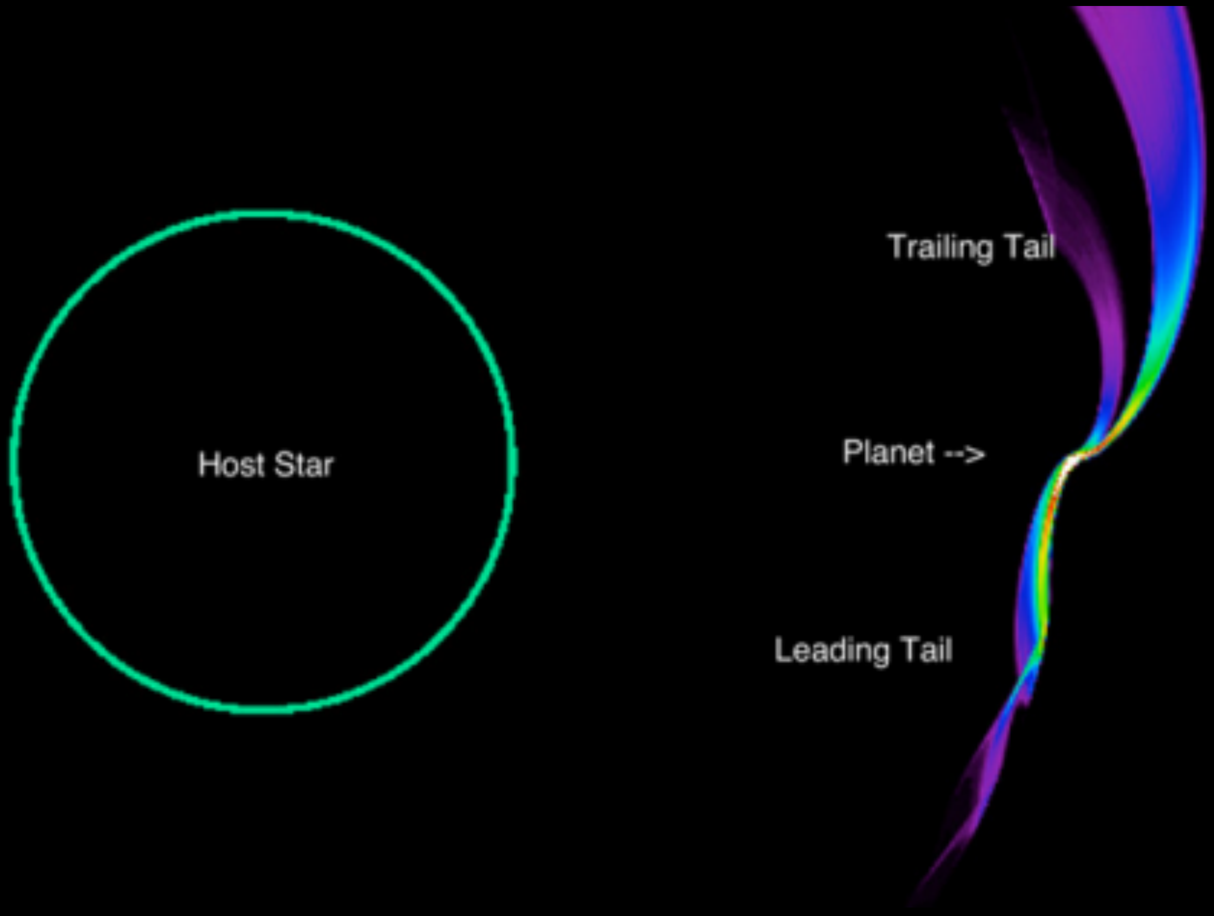

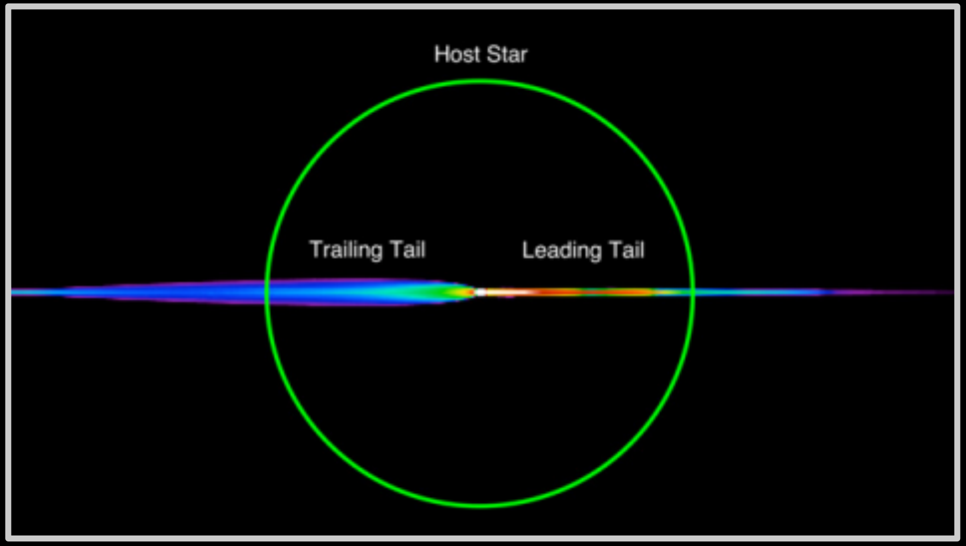

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Some Hot Jupiters have Close Friends

WASP-47: A HOT JUPITER SYSTEM WITH TWO ADDITIONAL PLANETS DISCOVERED BY K2

JULIETTE C. BECKER[1,6], ANDREW VANDERBURG[2,6], FRED C. ADAMS[1,3], SAUL A. RAPPAPORT[4], AND HANS MARTIN SCHWENGELER[5]

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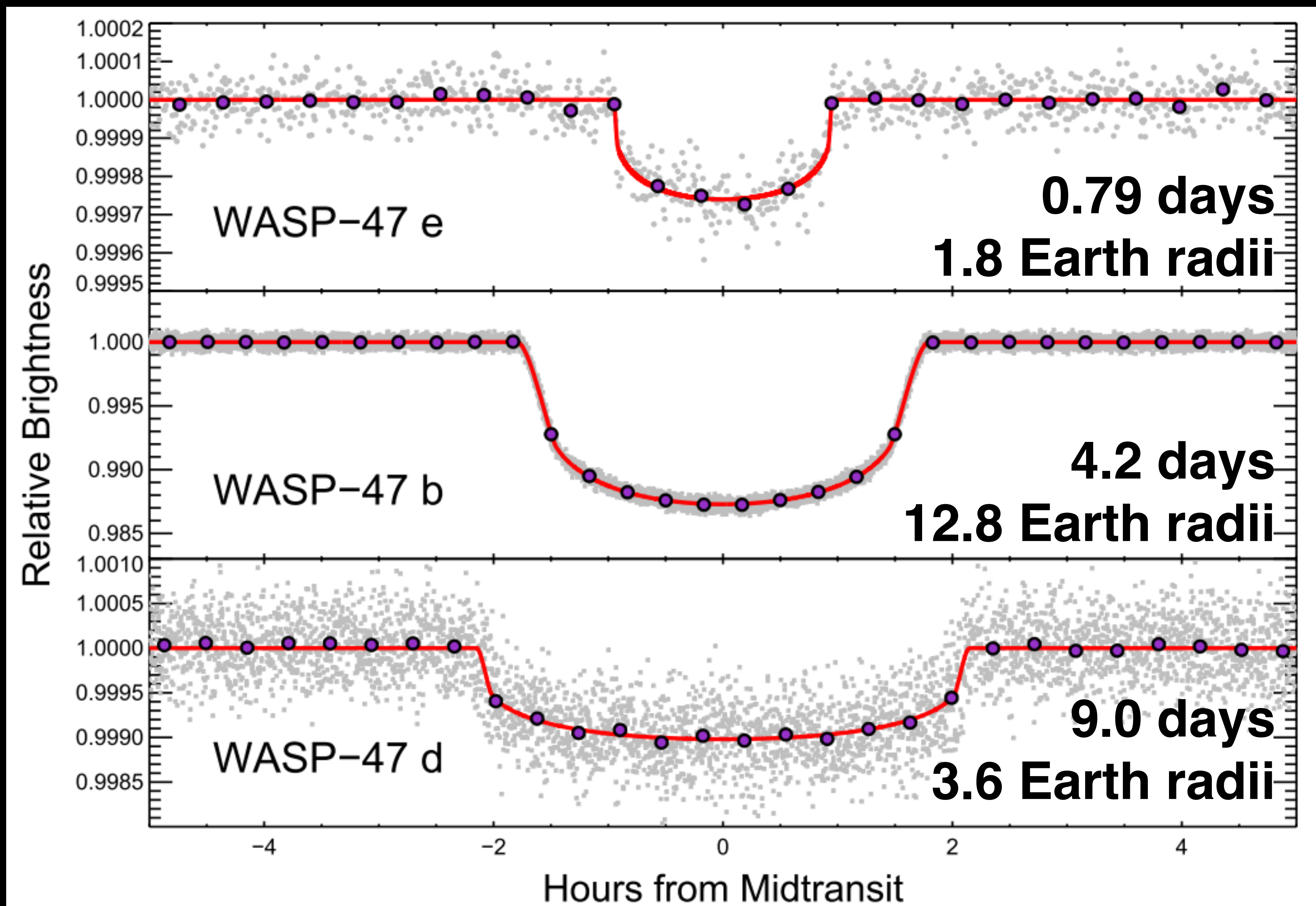

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Even Baby Stars Have Planets

A Neptune-sized transiting planet closely orbiting a 5–10-million-year-old star

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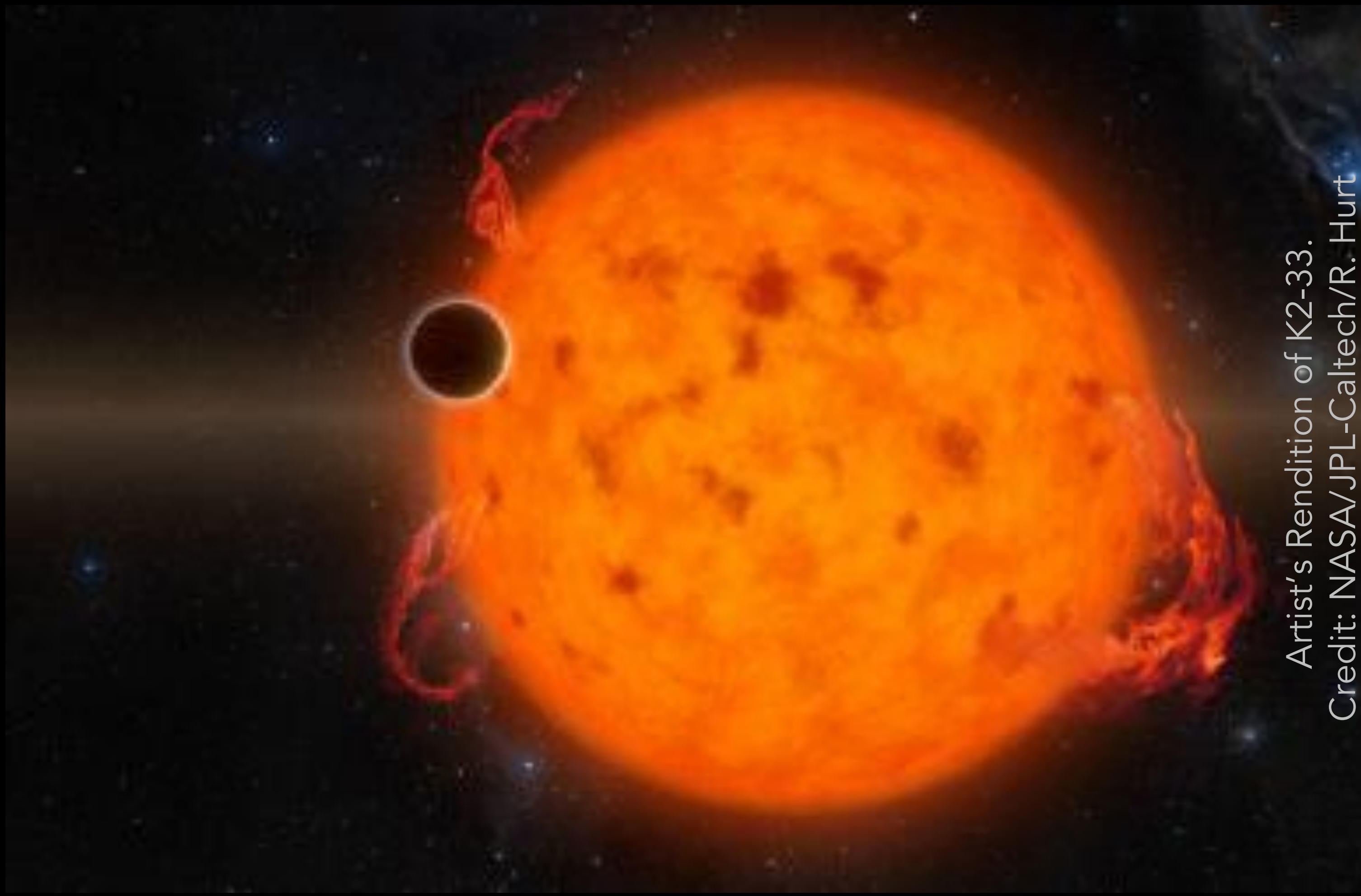

David+ 2016, Nature in press, arXiv:1606.06729

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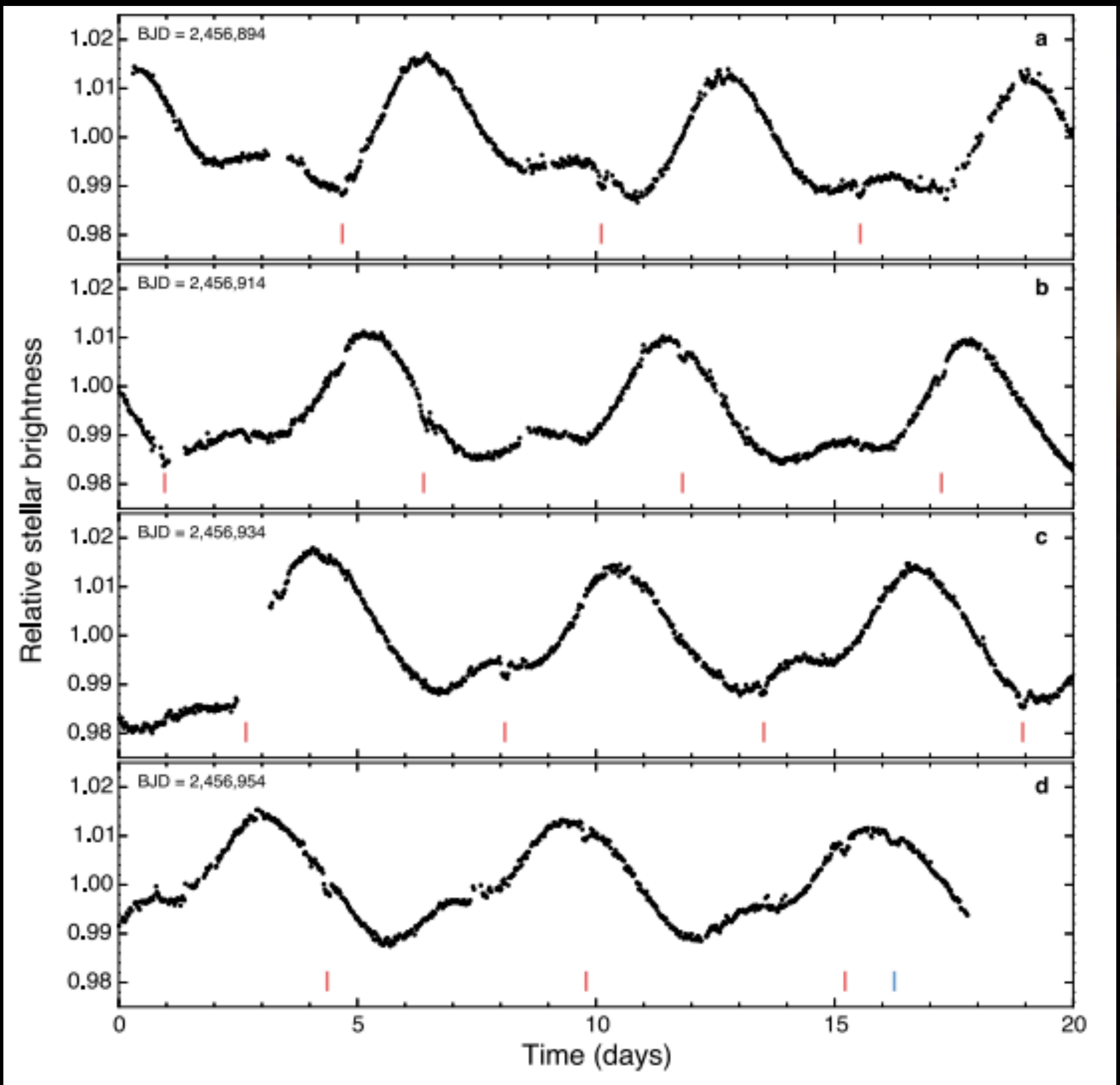

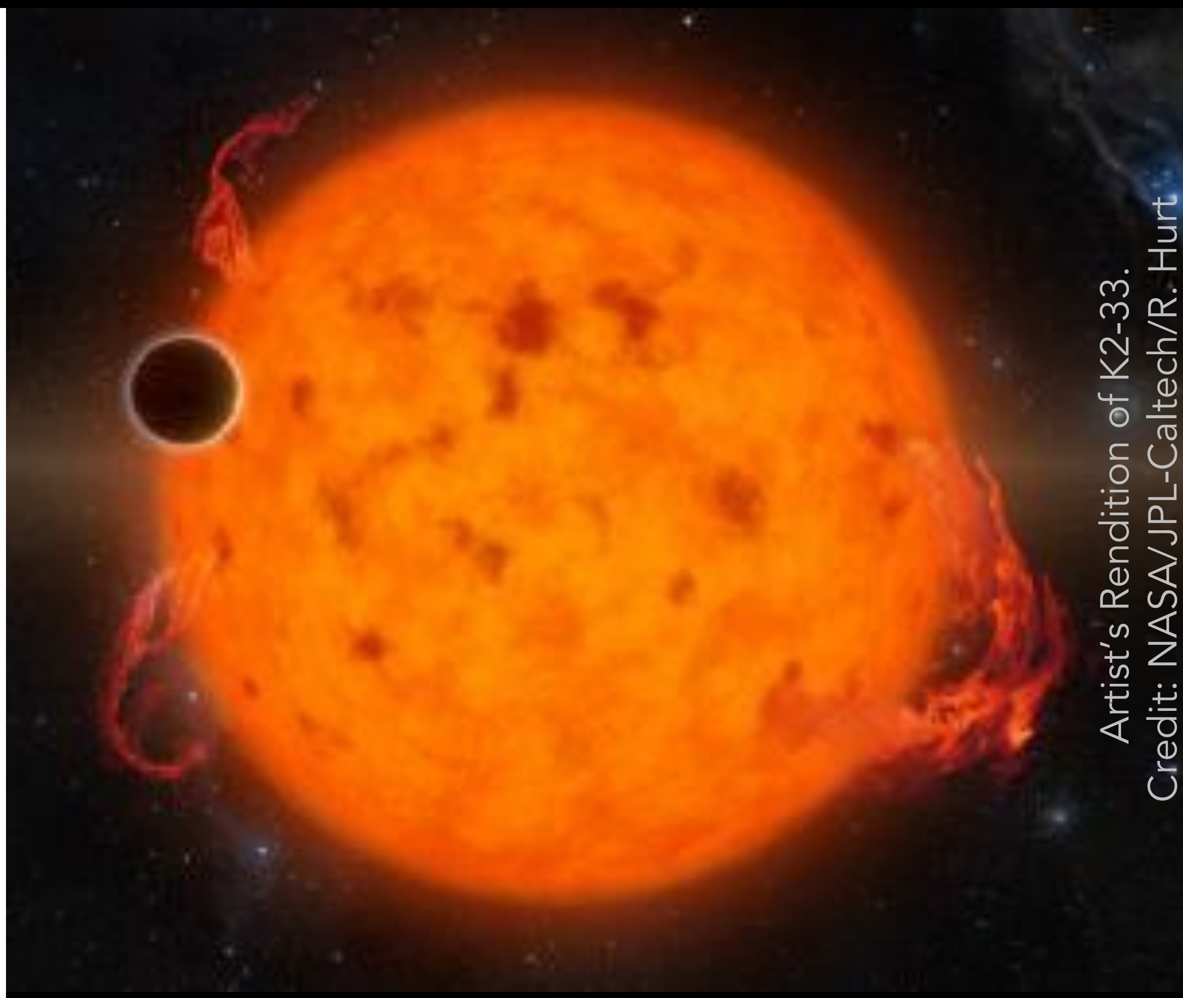

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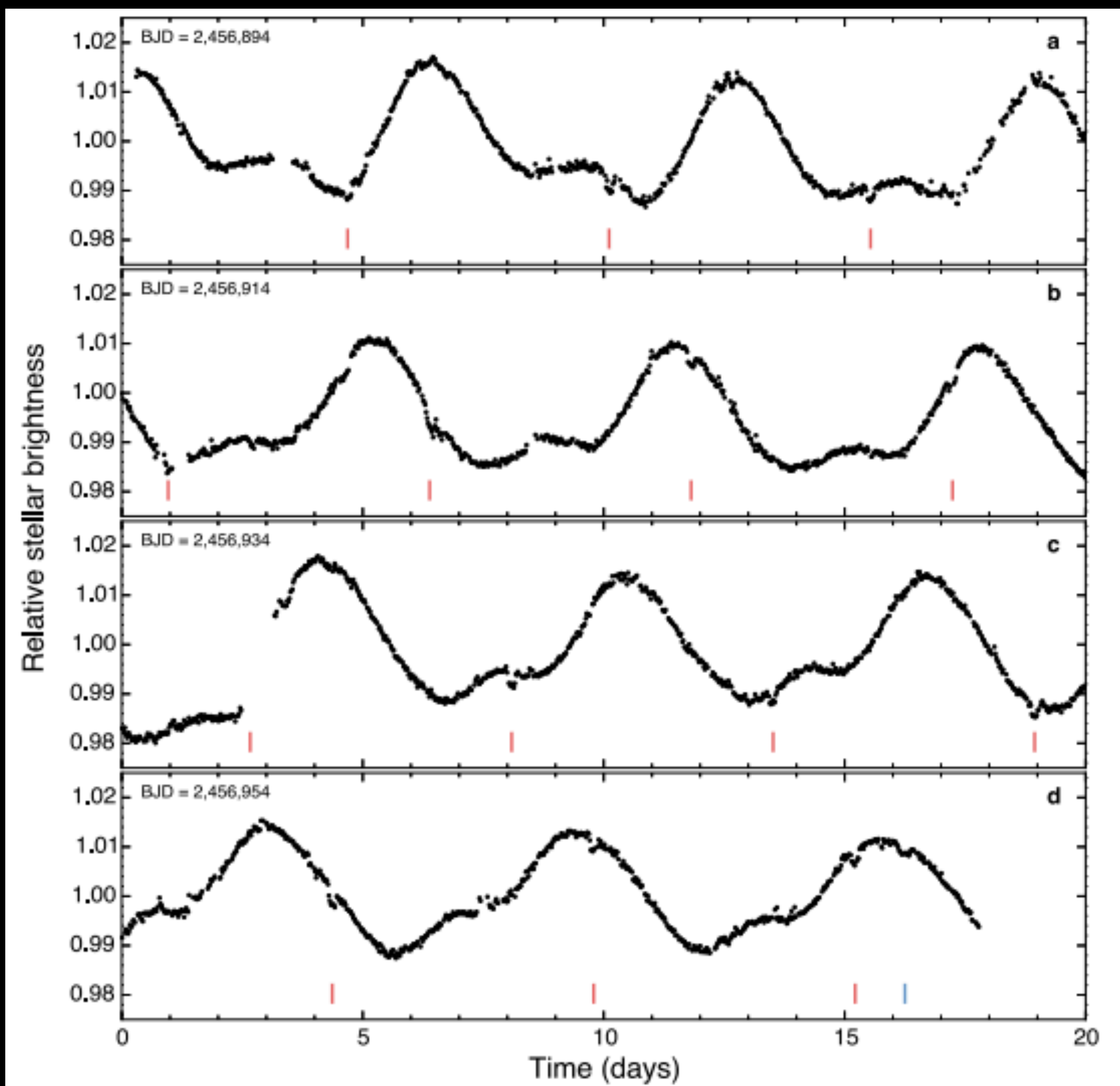

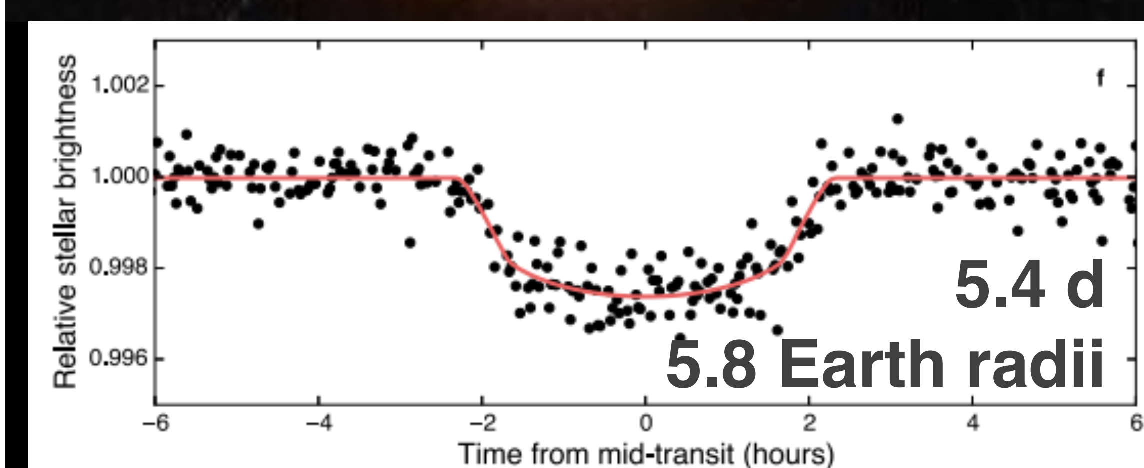

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Some Bright Stars Host Small Planets

TWO SMALL PLANETS TRANSITING HD 3167

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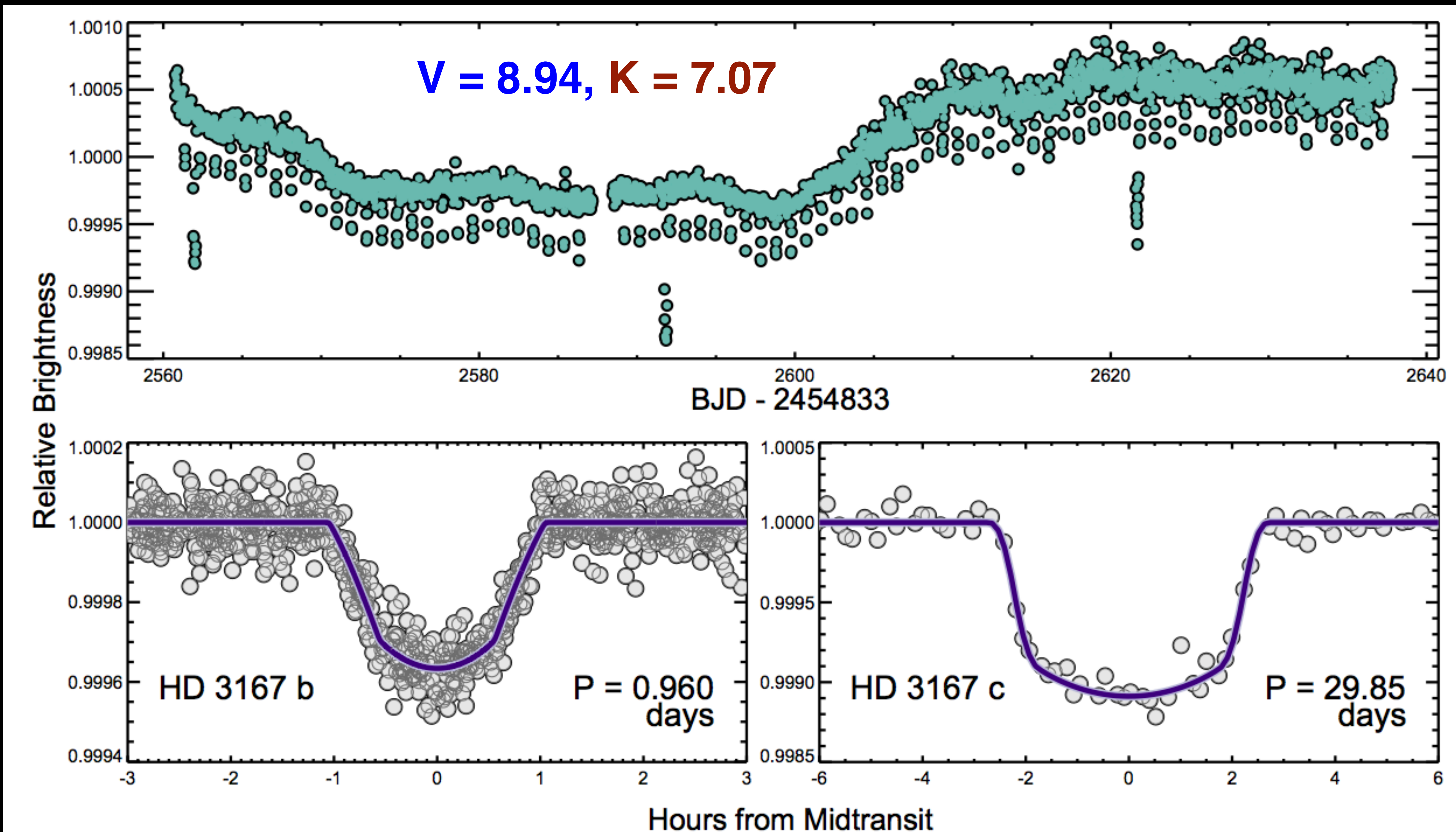

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K2 is expanding the sample of small planets orbiting bright stars

197 Candidates and 104 Validated Planets in K2's First Five Fields

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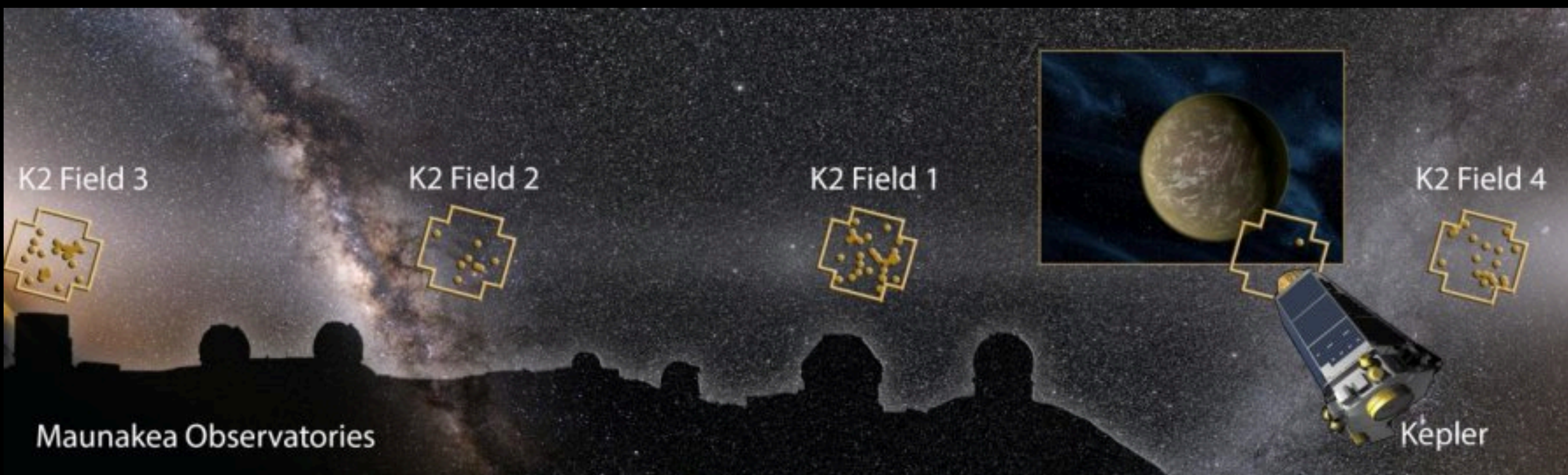

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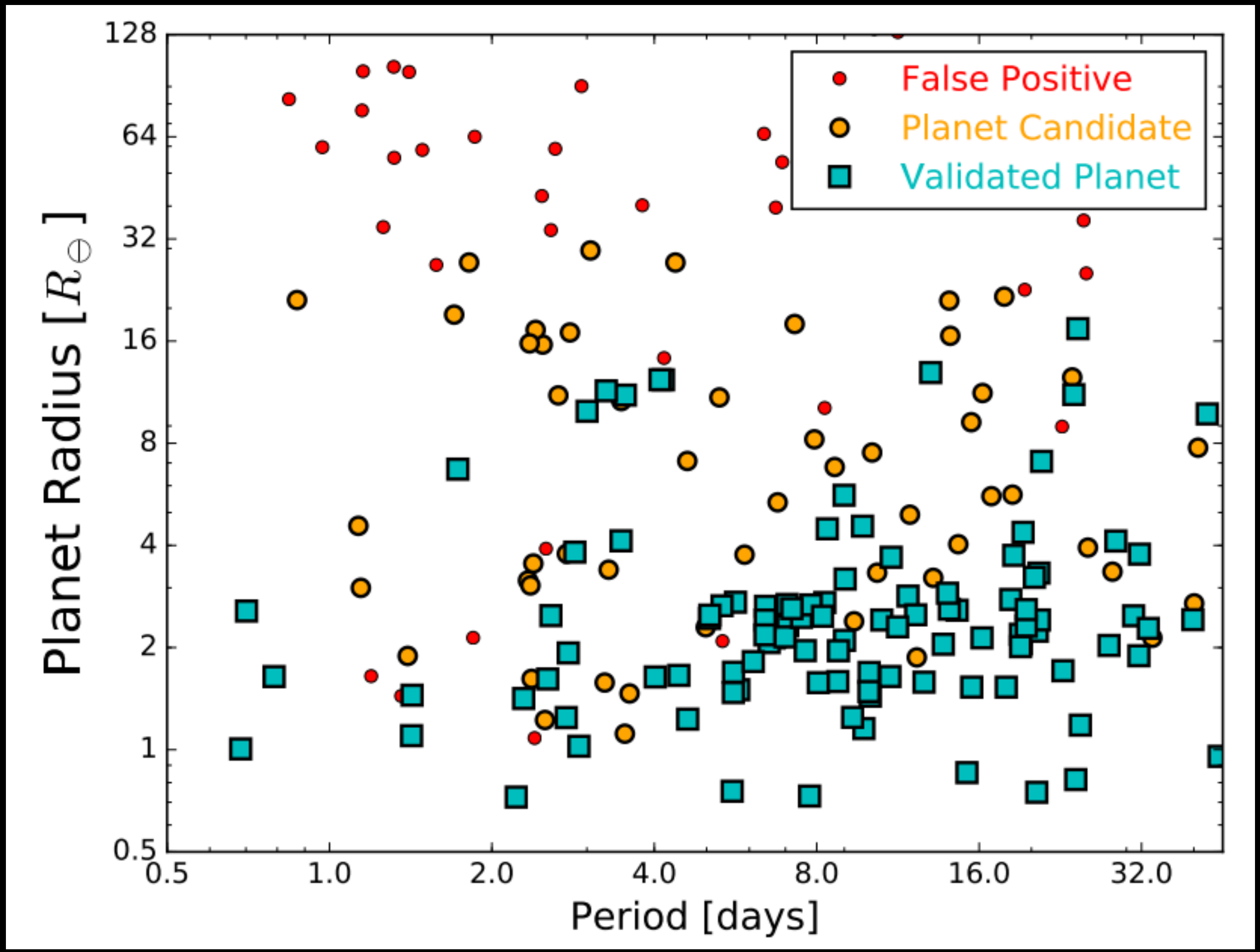

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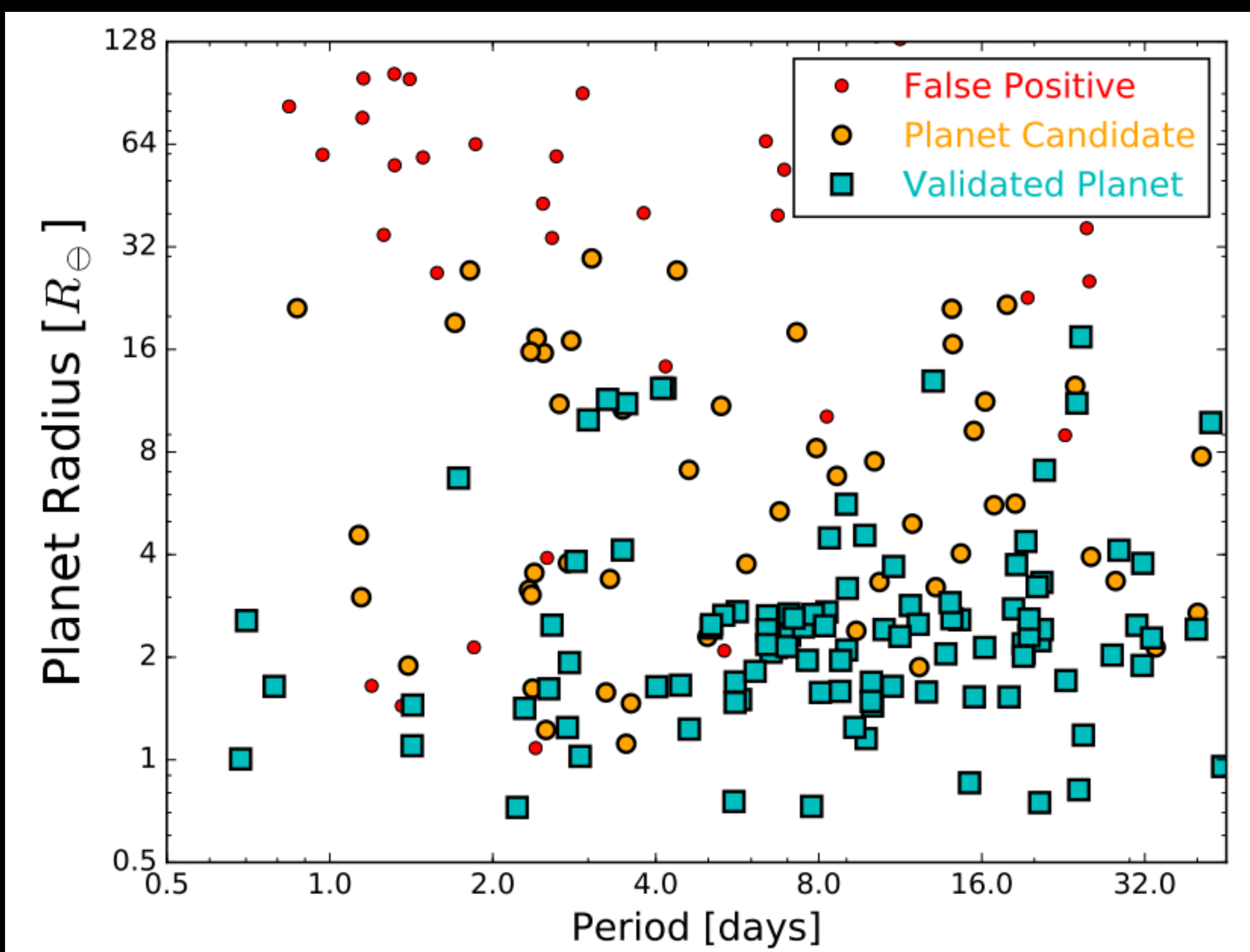

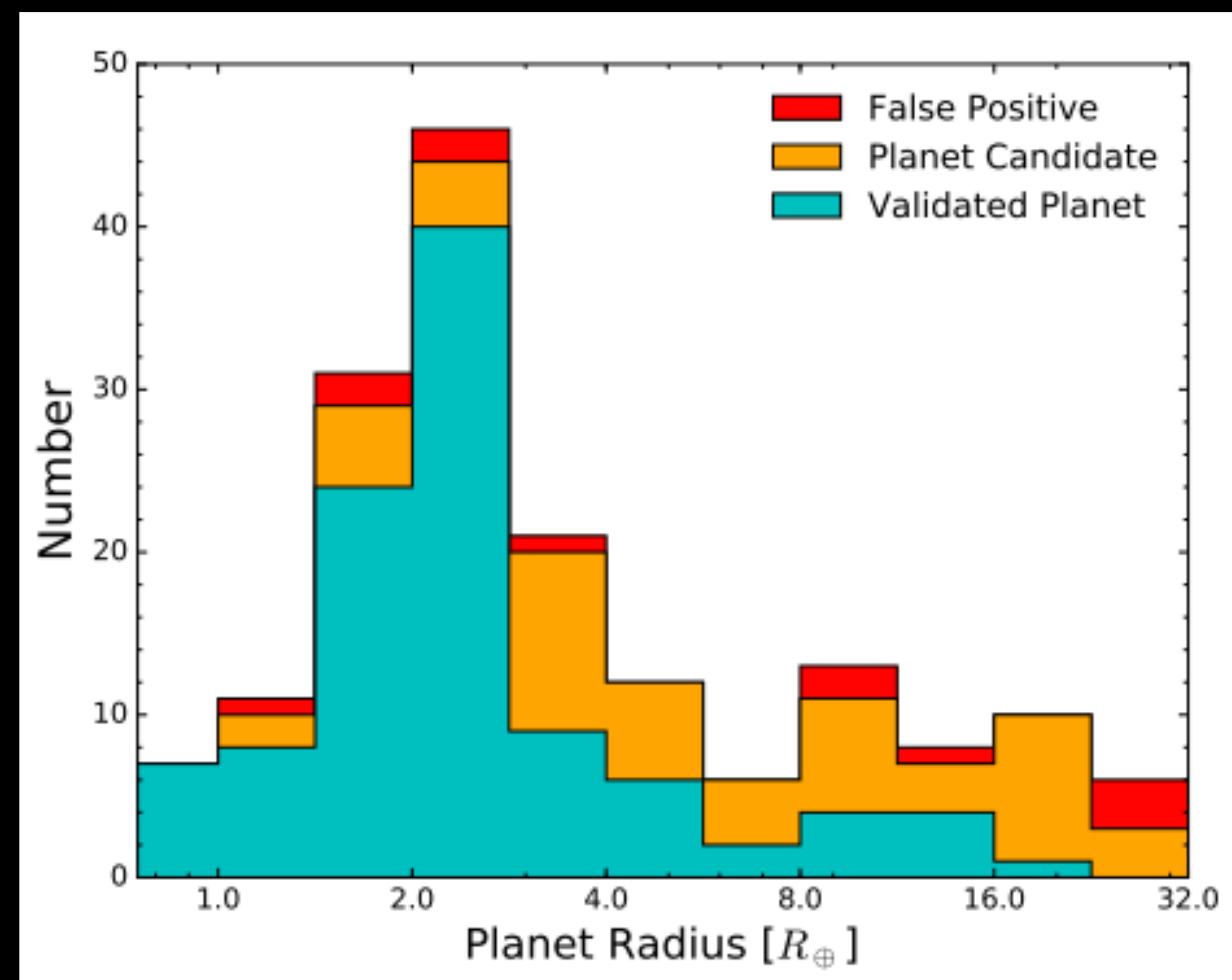

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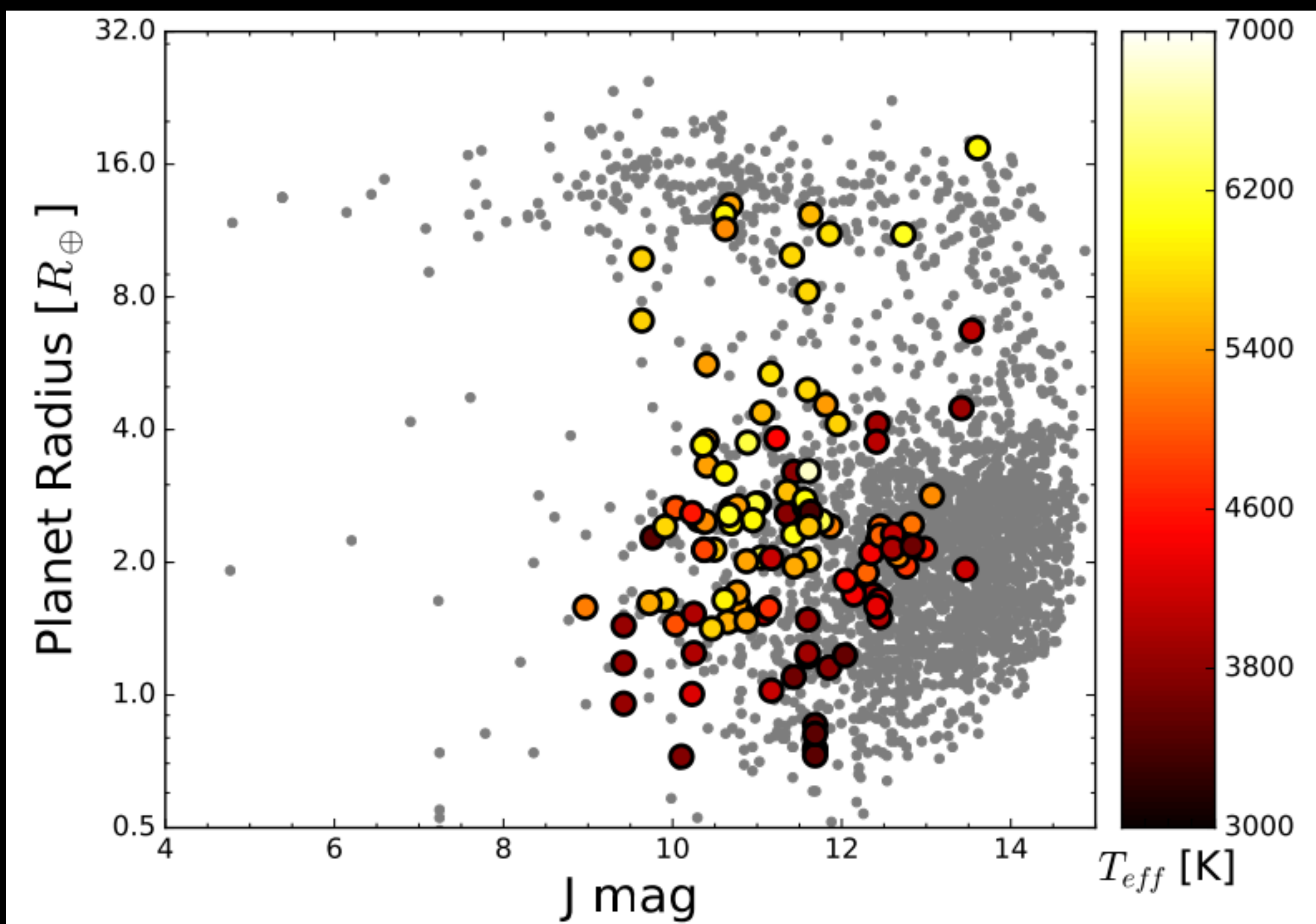

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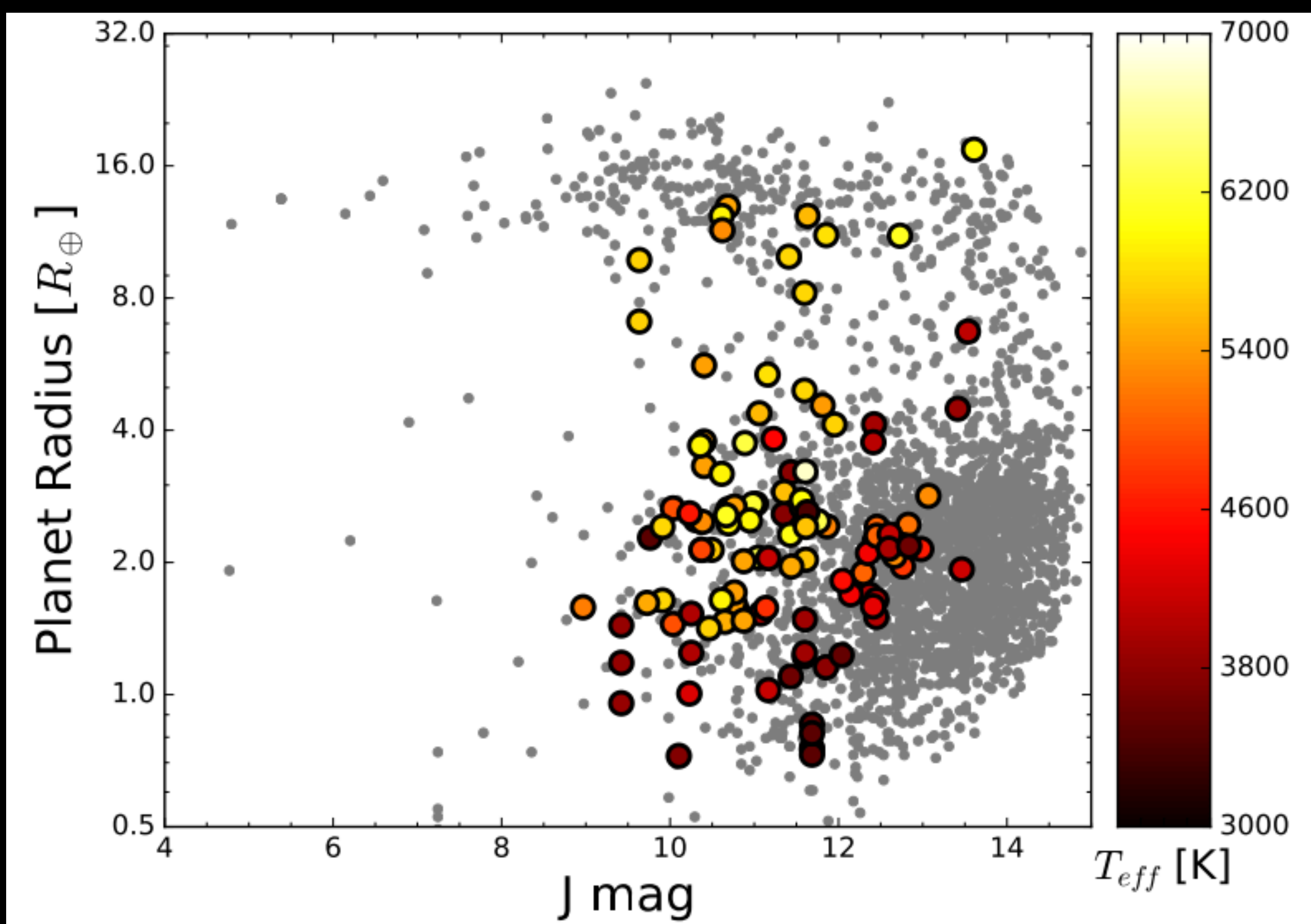

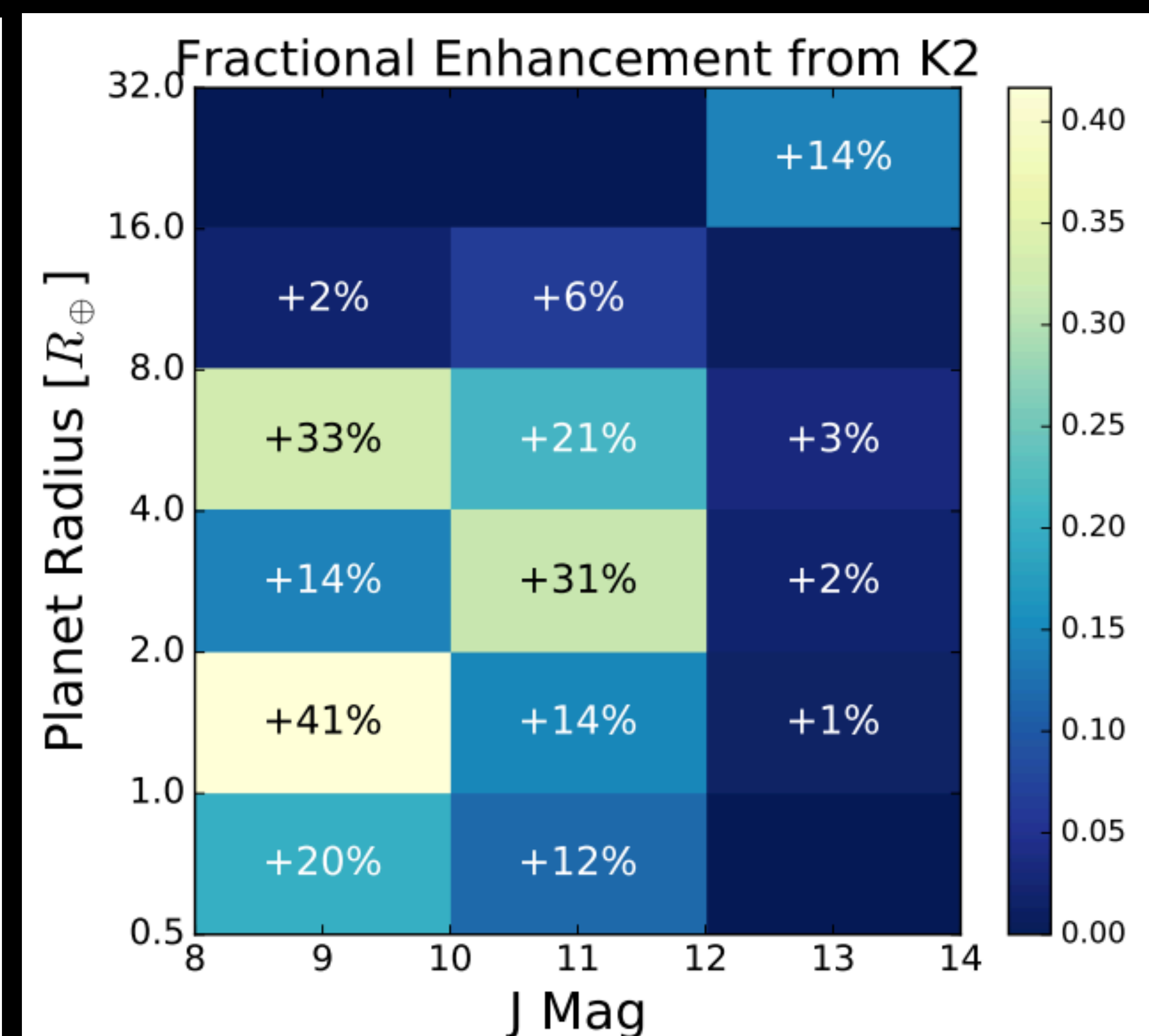

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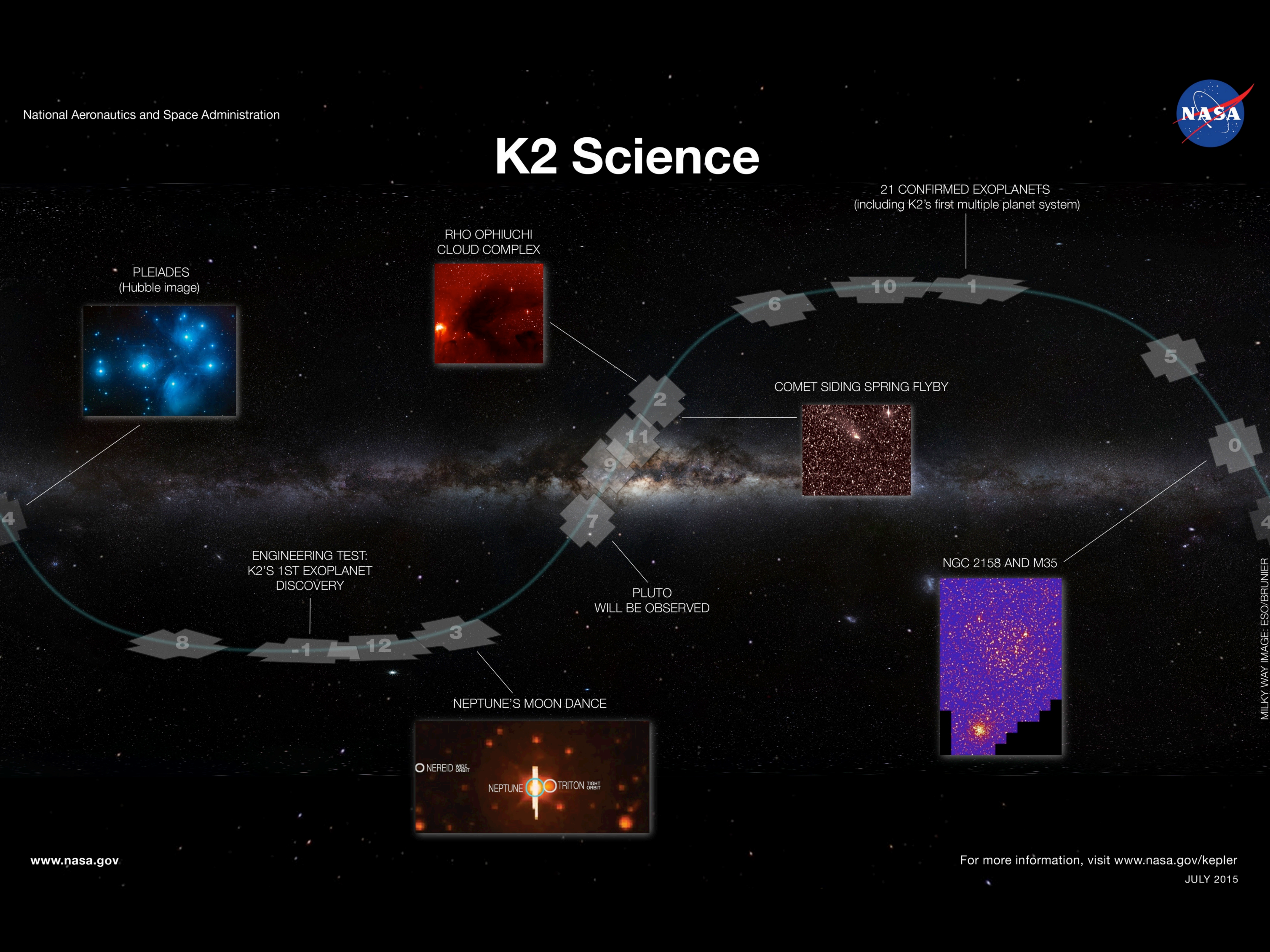
National Aeronautics and Space Administration
NASA
K2 Science
21 CONFIRMED EXOPLANETS
(including K2's first multiple planet system)
RHO OPHIUCHI
CLOUD COMPLEX
PLEIADES
(Hubble image)
COMET SIDING SPRING FLYBY
NGC 2158 AND M35
ENGINEERING TEST:
K2'S 1ST EXOPLANET
DISCOVERY
PLUTO
WILL BE OBSERVED
NEPTUNE'S MOON DANCE
NEREID WIDE ORBIT
NEPTUNE
TRITON TIGHT ORBIT
6
10
1
5
2
11
0
9
7
4
8
-1
12
3
MILKY WAY IMAGE: ESO/BRUNIER
www.nasa.gov
For more information, visit www.nasa.gov/kepler
JULY 2015

K2 Made the Honor Roll!

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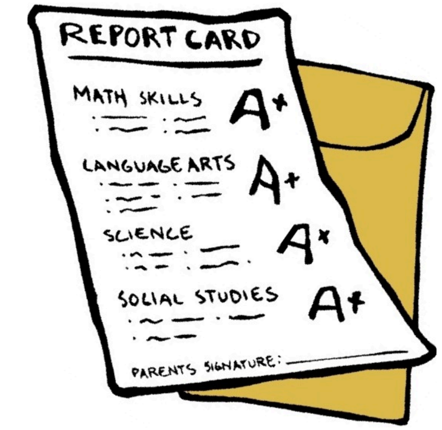

Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	E	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/VG
NuSTAR	E/VG	E/VG	E	E/VG
Spitzer	E/VG	E/VG	VG	E/VG
Fermi	E/VG	E/VG	VG	E/VG

Scores: E=Excellent, E/VG = Excellent/Very Good, VG=Very Good

2016 NASA Senior Review Main Panel Report

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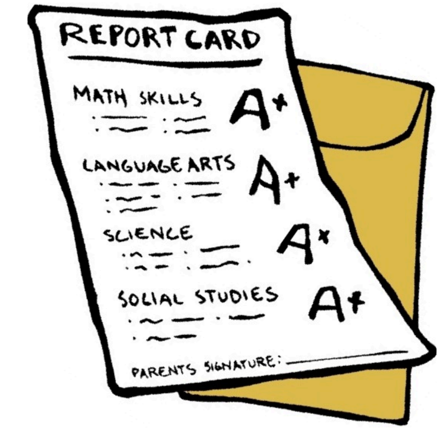


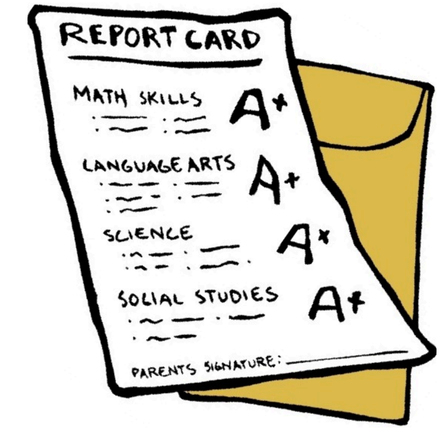
Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	E	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/VG
NuSTAR	[illegible]	E/VG	E	E/VG
Spitzer	E/VG	E/VG	[illegible]	E/VG
Fermi	E/VG	E/VG	VG	E/VG

“CLEVERLY REPURPOSED”

Scores: E=Excellent, E/VG = Excellent/Very Good, VG=Very Good

2016 NASA Senior Review Main Panel Report

K2 Made the Honor Roll!



Criteria	**Science (A)**	**Relevance (B)**	**Cost (C)**	**Total**
K2	E	E	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/VG
NuSTAR	E/VG	E/VG	E	E/VG
Spitzer	E/VG	E/VG	VG	E/VG
Fermi	E/VG	E/VG	VG	E/VG

Scores: E=Excellent, E/VG = Excellent/Very [illegible], VG=Very [illegible]

"CLEVERLY REPURPOSED"

"an ideal example of why NASA continues to operate missions after their prime phase"

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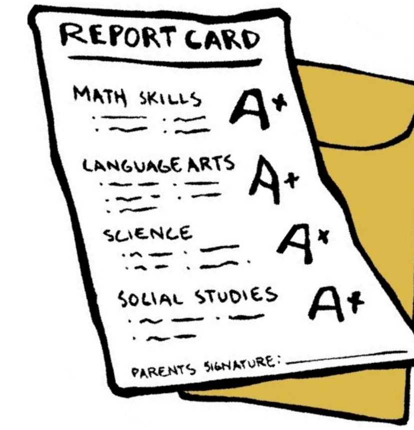

Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	E	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/VG
NuSTAR	E/VG	E/VG	E	E/VG
Spitzer	E/VG	E/VG	VG	E/VG
Fermi	E/VG	E/VG	VG	E/VG

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"the team has exceeded all expectations"

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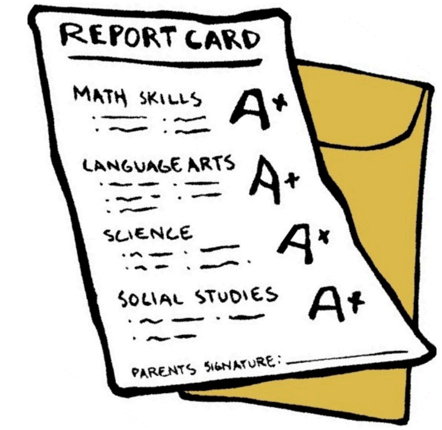

Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	E	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	[illegible]
NuSTAR	[illegible]	E/VG	E	[illegible]
Spitzer	E/VG	E/VG	[illegible]	[illegible]
Fermi	E/VG	E/VG	VG	[illegible]

Scores: E [illegible] = Excellent/Very [illegible]

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2016 NASA Senior Review Main Panel Report

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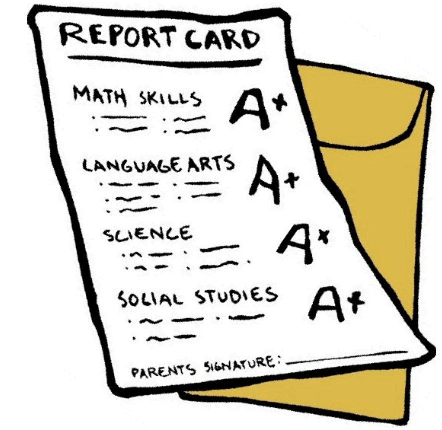

Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	[illegible]	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/V[illegible]
NuSTAR	[illegible]VG	E/VG	E	E/V[illegible]
Spitzer	E/VG	E/VG	[illegible]VG	E/V[illegible]
Fermi	E/VG	E/VG	VG	E/V[illegible]

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"DRAMATIC OBSERVATIONS"

"the team has exceeded all expectations"

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2016 NASA Senior Review Main Panel Report

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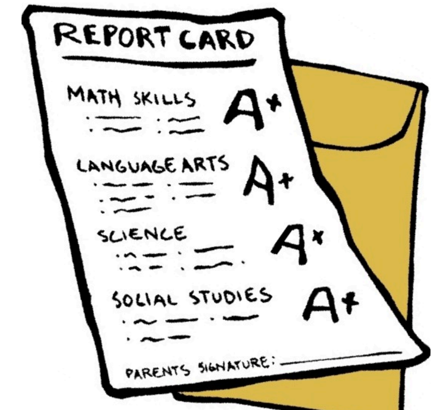

The SR2016 panel recommends full funding of the completion of the K2 plan for the next two years.

Criteria	Science (A)	Relevance (B)	Cost (C)	Total
K2	E	[illegible]	E	E
Swift	E/VG	E	E	E
XMM	E/VG	E/VG	E	E/[illegible]
NuSTAR	[illegible]VG	E/VG	E	E/VG
Spitzer	E/VG	E/VG	[illegible]VG	E/V[illegible]
Fermi	E/VG	E/VG	VG	E/V[illegible]

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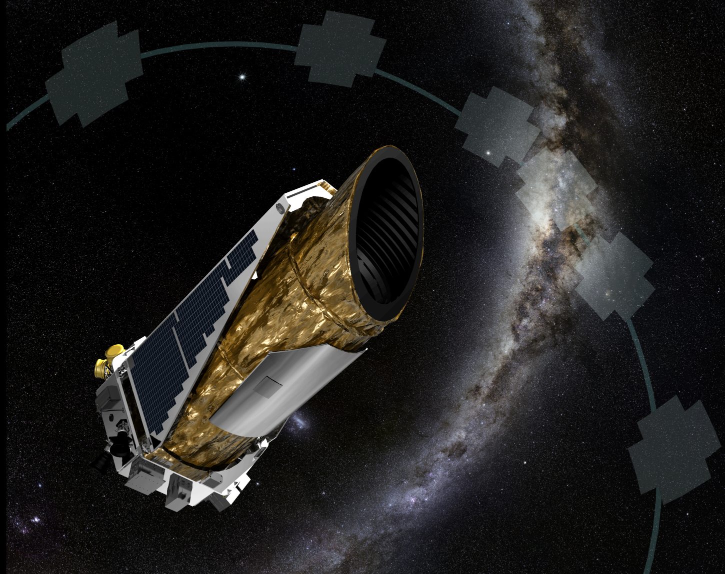
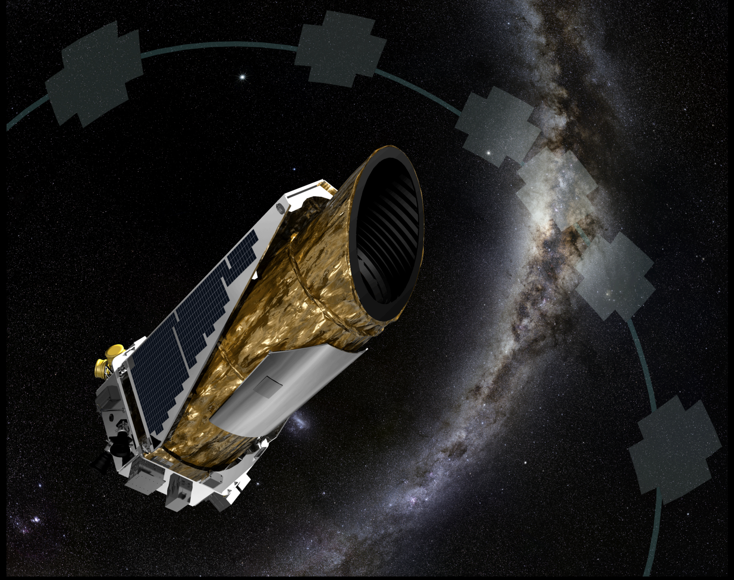


K2

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

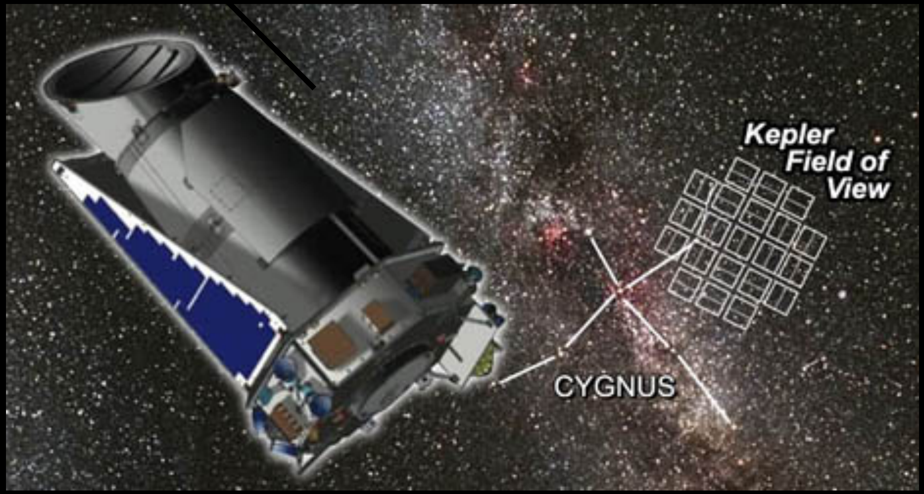
Kepler



K2

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Kepler



TESS

the

TESS

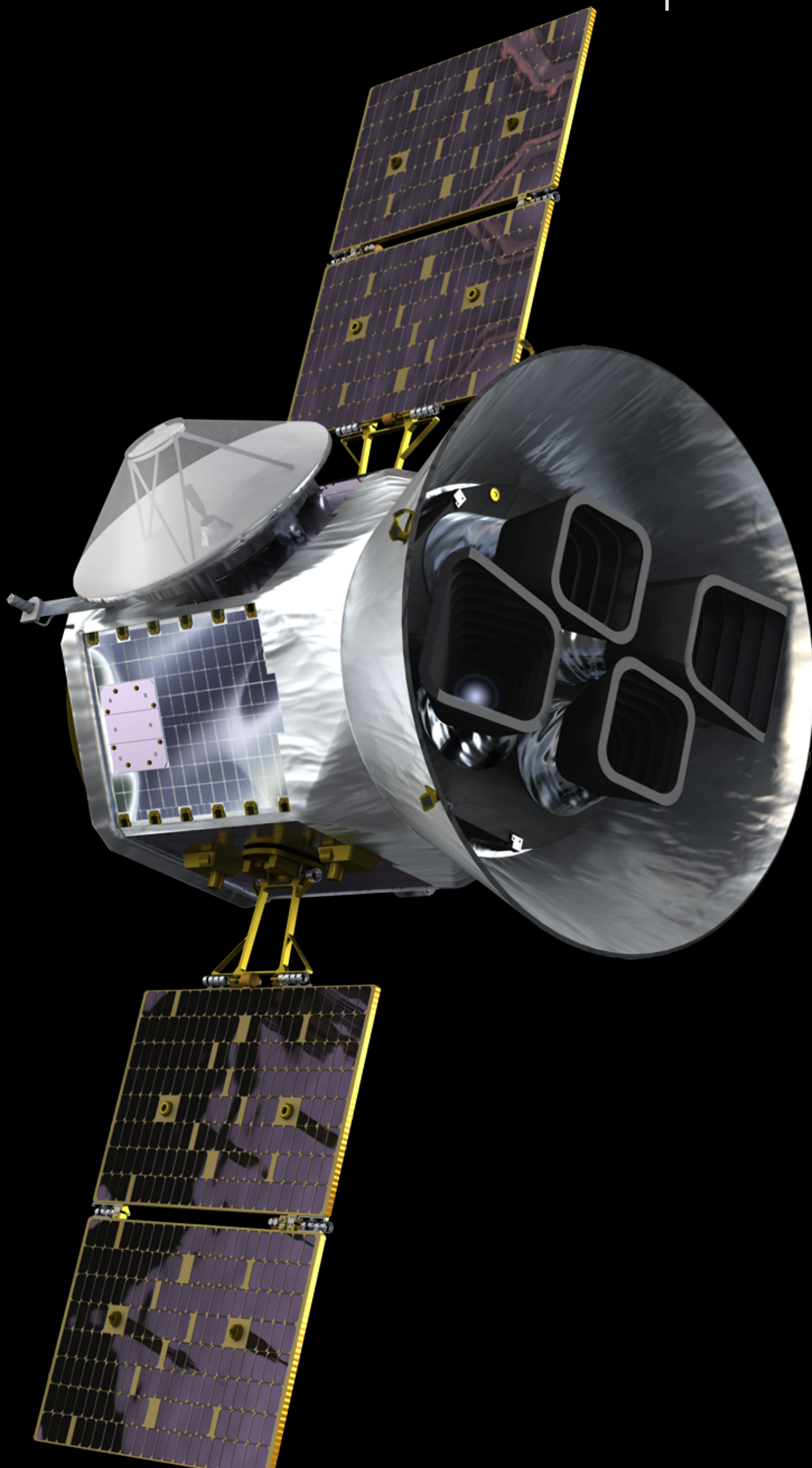
mission

@TESS_NASA
(Matt Ritsko at Goddard)

@TESSatMIT
(Gabi Serrato Marks at MIT)

Zach Berta-Thompson
Torres Exoplanet Fellow at Massachusetts Institute of Technology
Assistant Professor at University of Colorado, Boulder

TESS Slides from Zach Berta-Thompson



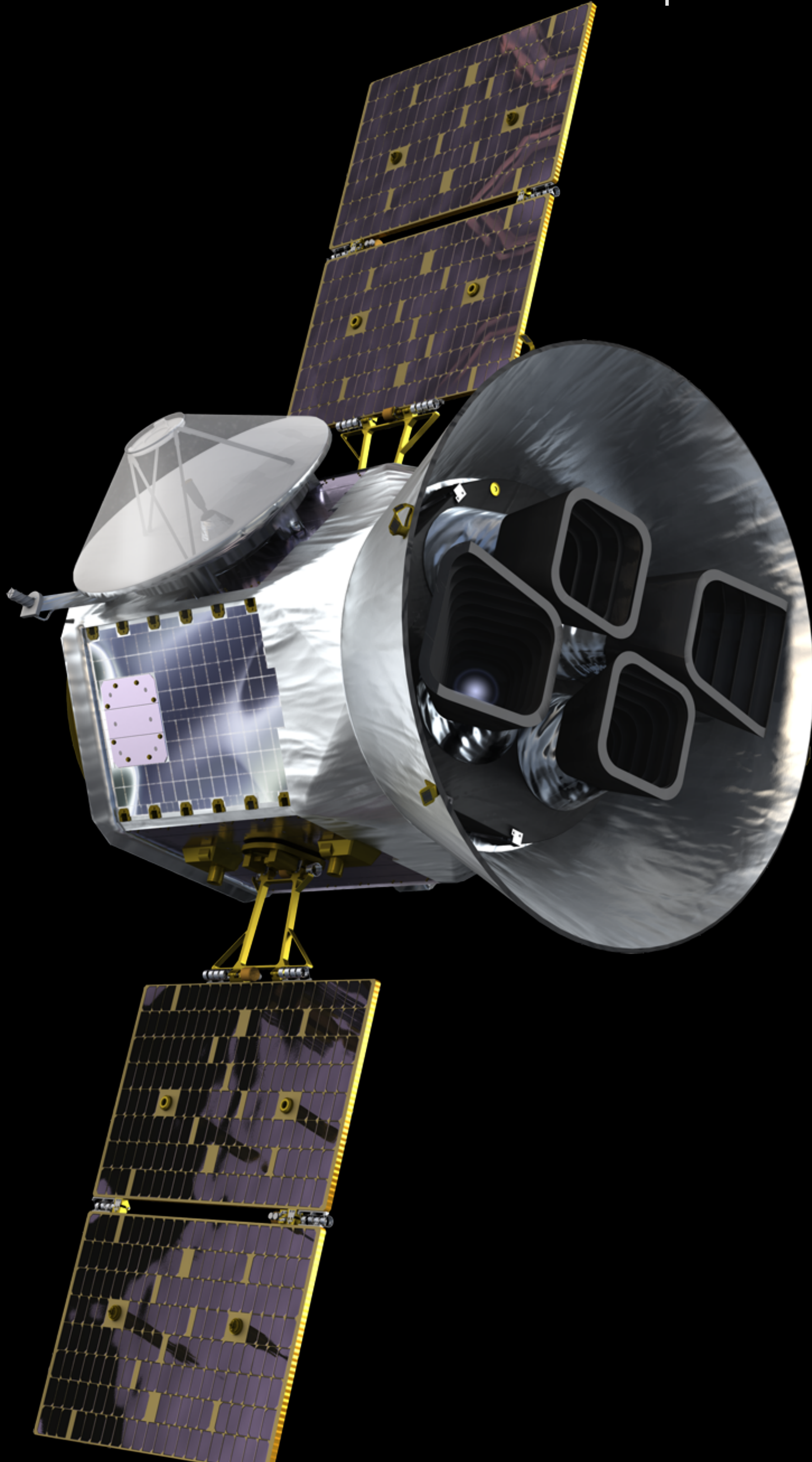
TESS

Explorer Mission

*launch in **2017**,*
to find hundreds of nearby small exoplanets amenable to detailed characterization

Ricker et al., *JATIS*, (2014)

TESS Slides from Zach Berta-Thompson



TESS

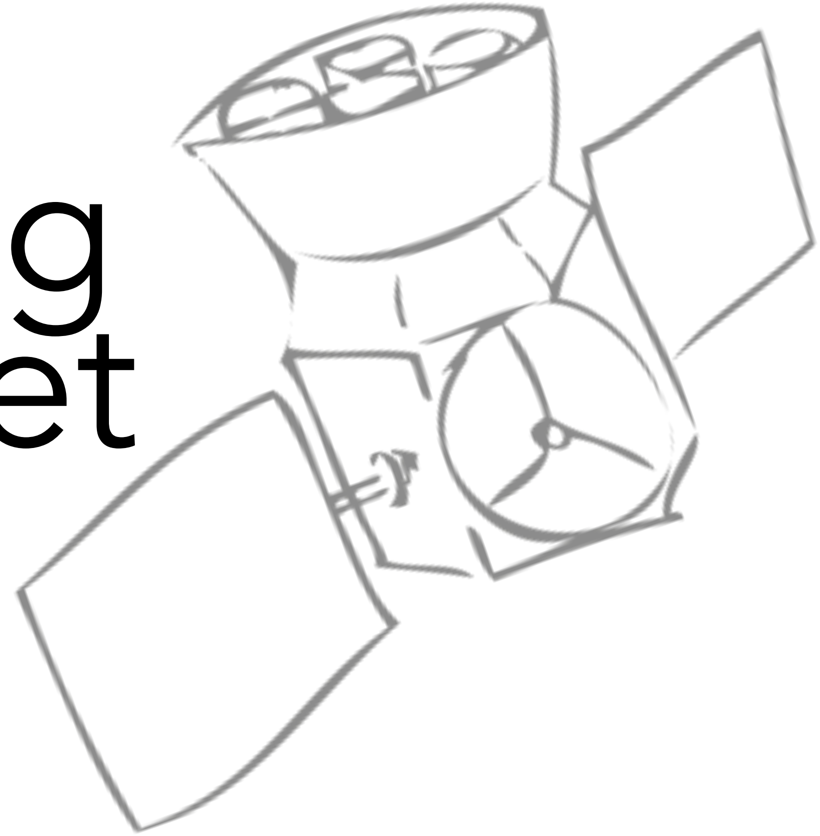
George Ricker (P.I.)
Roland Vanderspek (Deputy P. I.)
Massachusetts Institute of Technology

science center shared between
MIT + Harvard/Smithsonian CfA

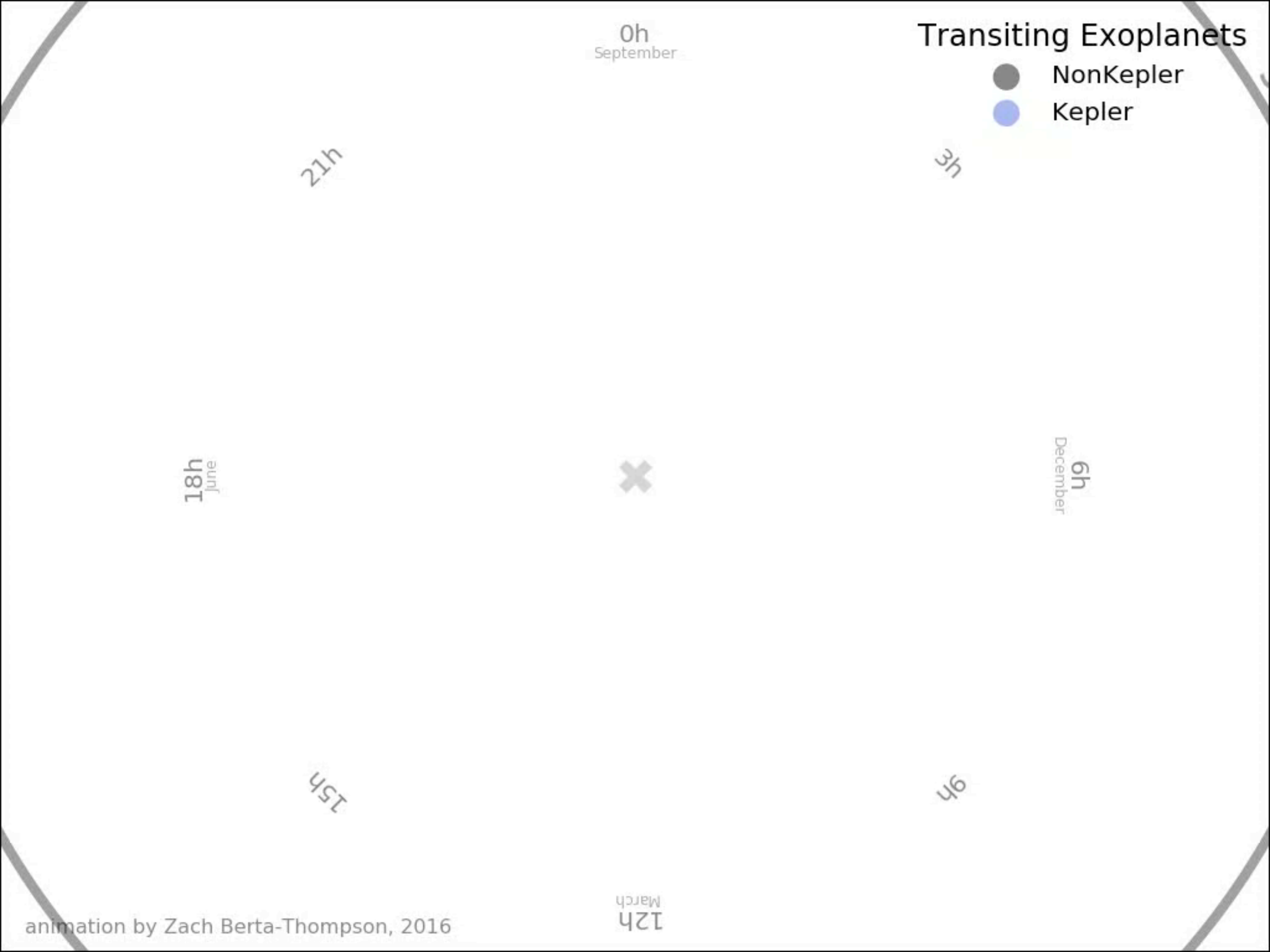
collaboration including:
NASA Goddard, NASA Ames, MIT Lincoln Lab, Orbital Sciences, STScI, SAO, MPIA-Germany, Las Cumbres Observatory, Geneva Observatory, OHP-France, University of Florida, Aarhus University-Denmark, Harvard College Observatory, Vanderbilt University,

Ricker et al., *JATIS*, (2014)

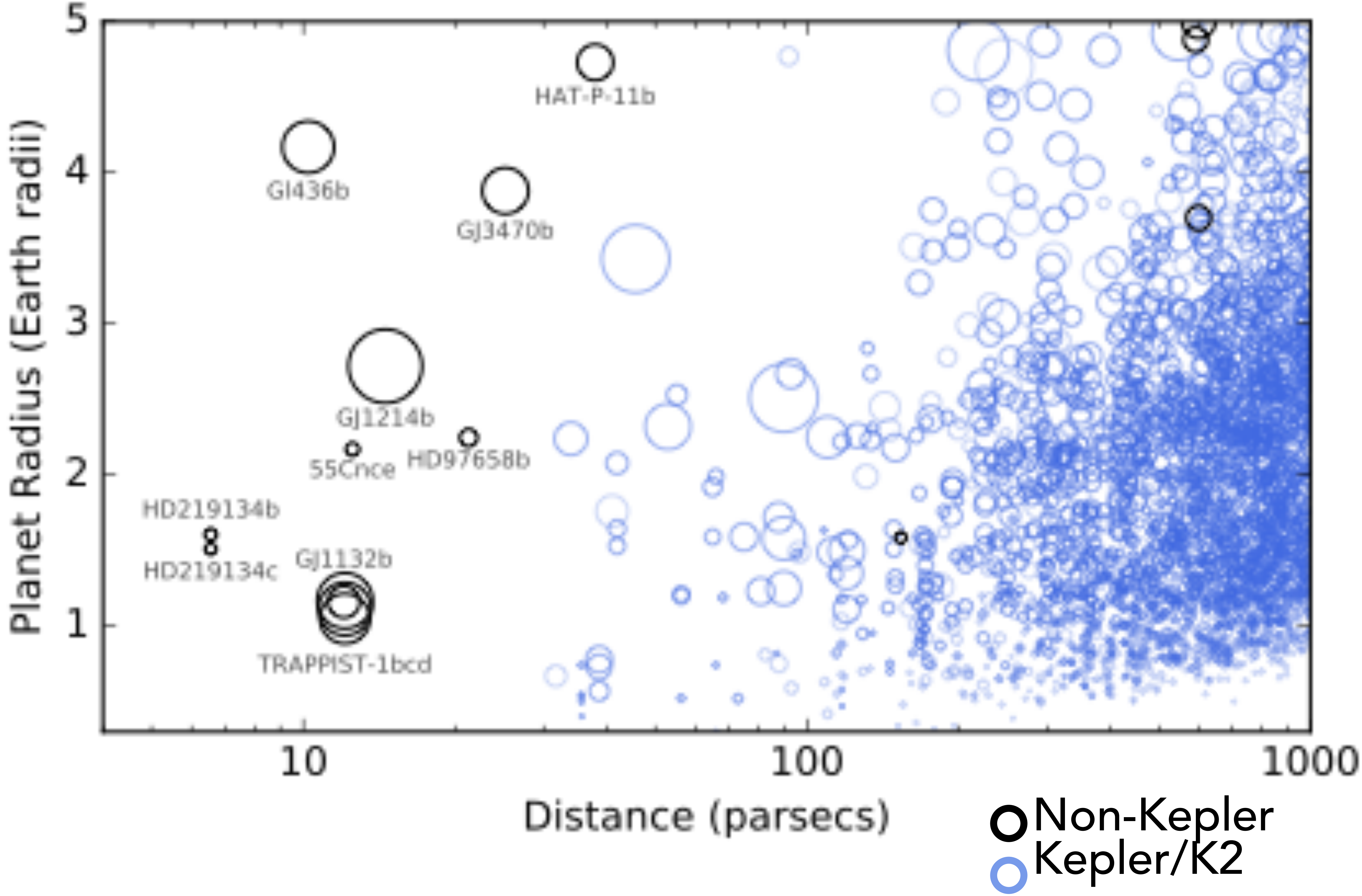
Transiting
Exoplanet
Survey
Satellite



Why do we need it?
How will it work?
What data will it collect?
When does it happen?

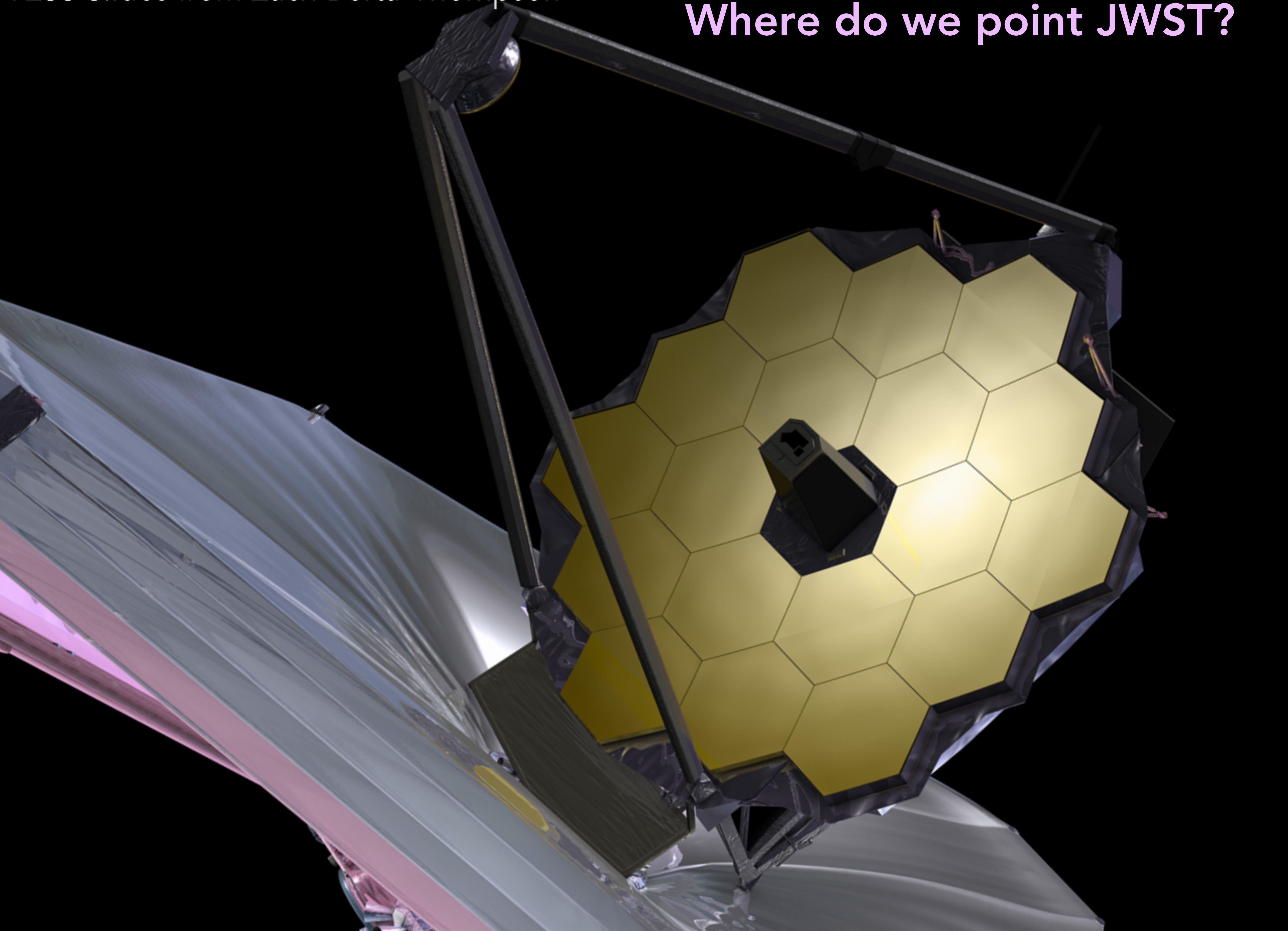

Transiting Exoplanets
NonKepler
Kepler
0h
September
3h
6h
December
9h
12h
March
15h
18h
June
21h
animation by Zach Berta-Thompson, 2016

TESS Slides from Zach Berta-Thompson



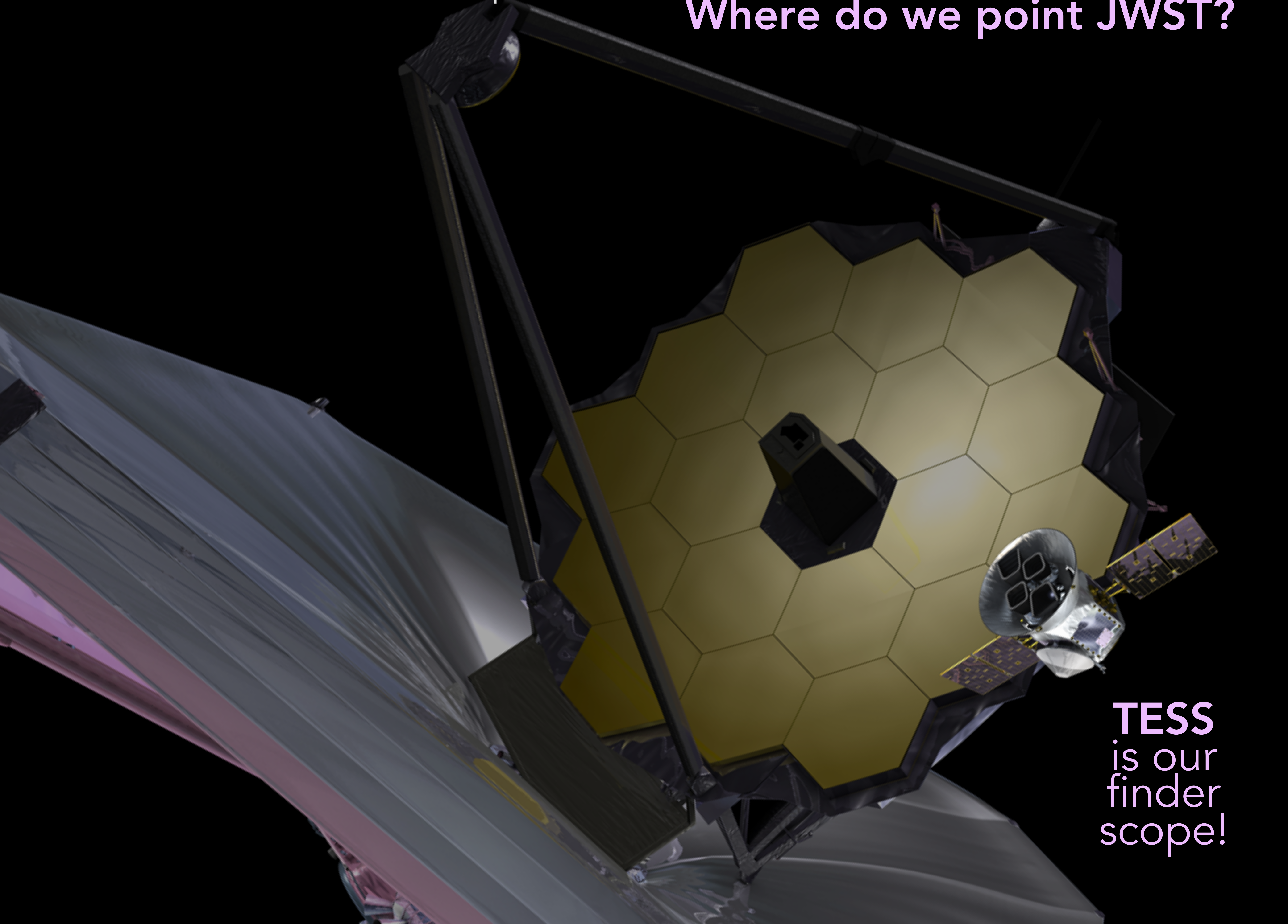
TESS Slides from Zach Berta-Thompson

Where do we point JWST?



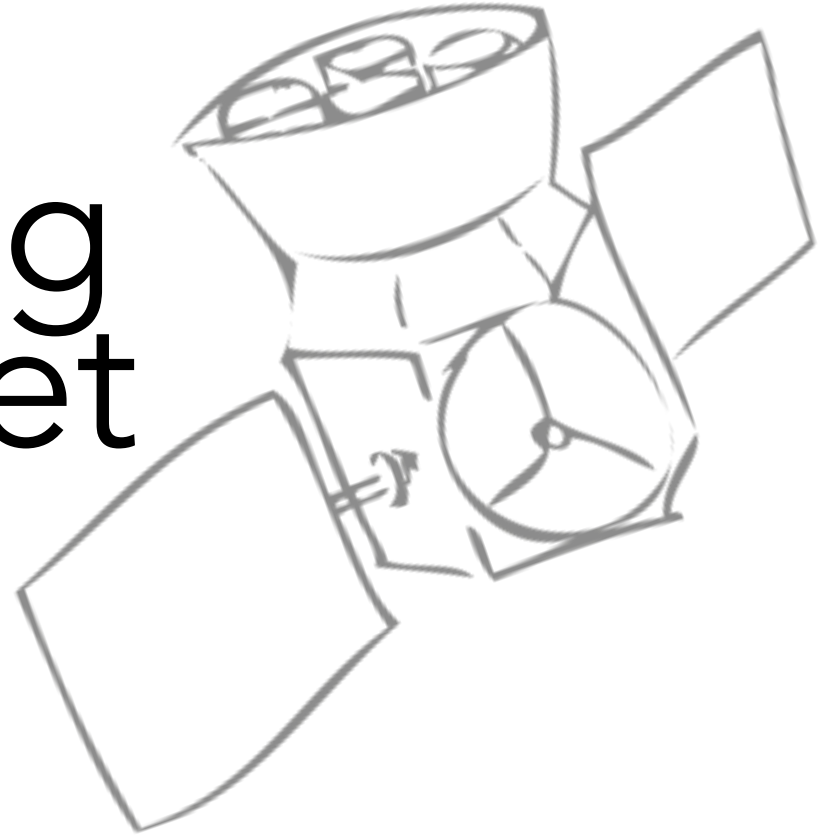
TESS Slides from Zach Berta-Thompson

Where do we point JWST?



TESS Slides from
Zach Berta-Thompson

Transiting Exoplanet Survey Satellite



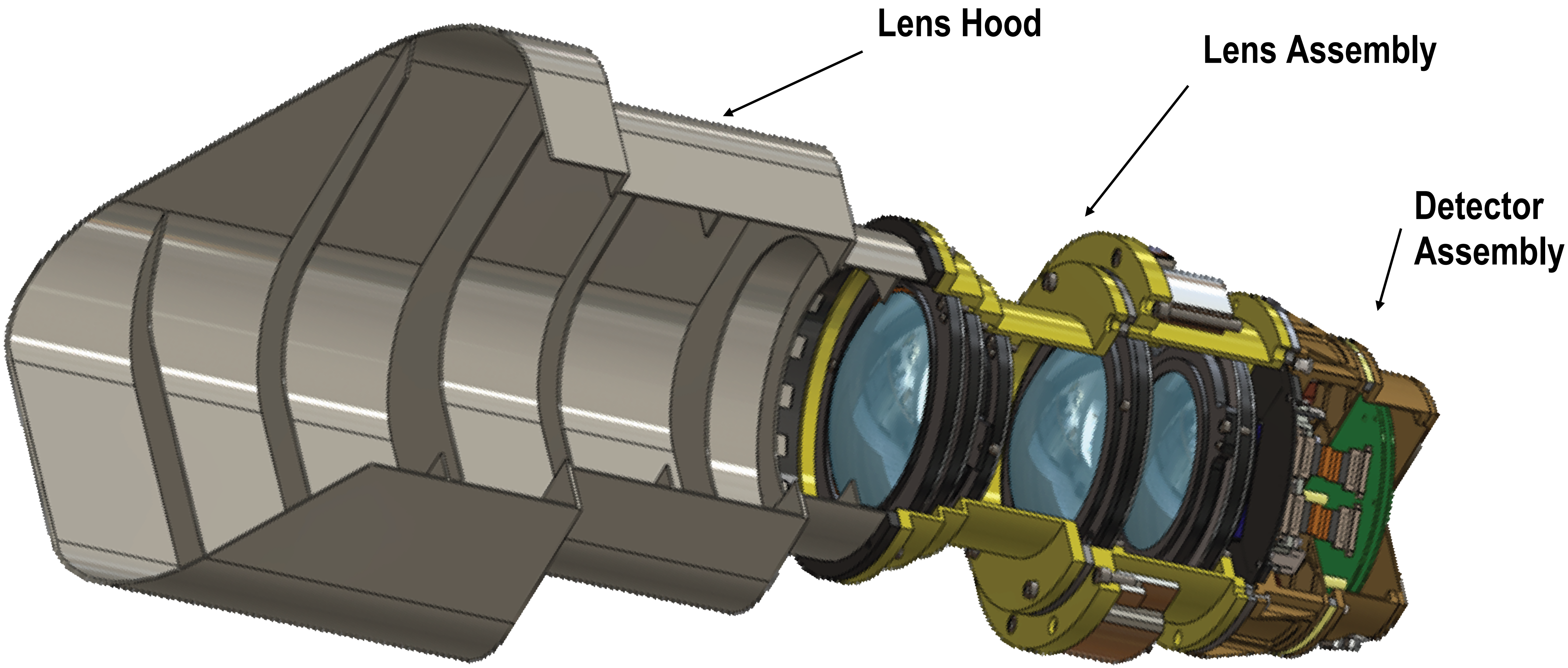
Why do we need it?

How will it work?

What data will it collect?

When does it happen?

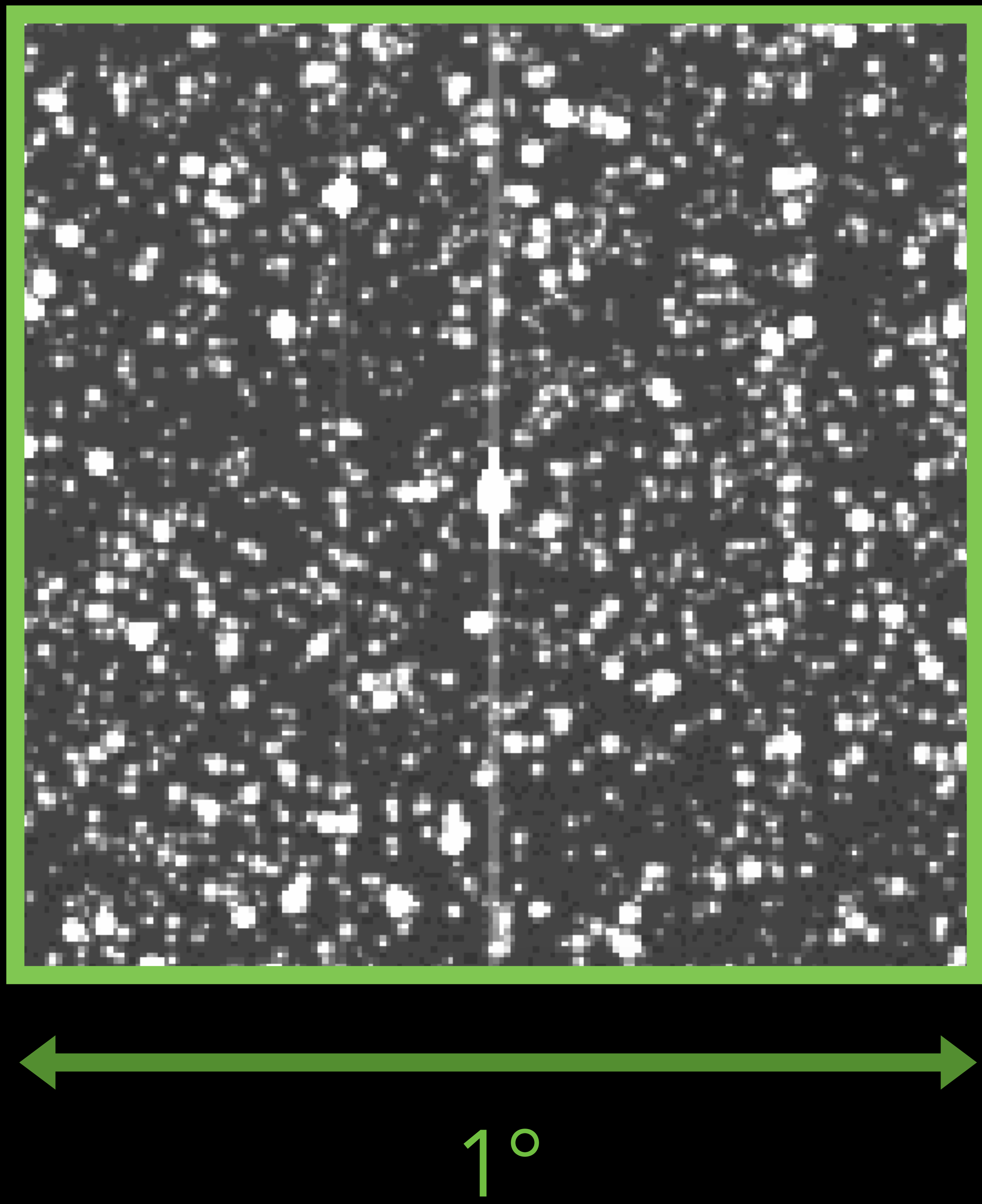
TESS will measure the brightness of stars.



10.5 cm diameter, 24°x24° field of view

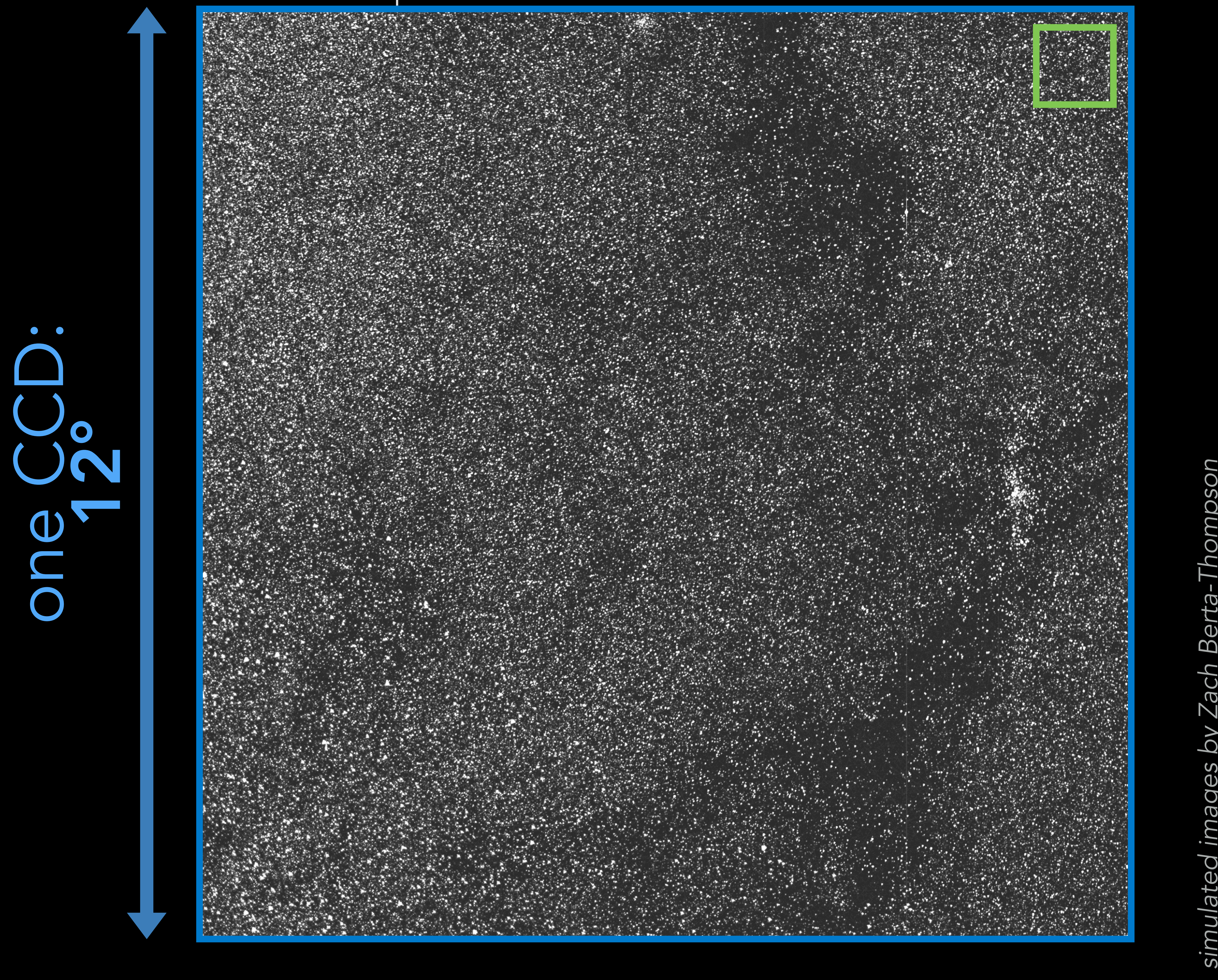
Ricker et al. (2014), Sullivan et al. (2015)

TESS Slides from Zach Berta-Thompson



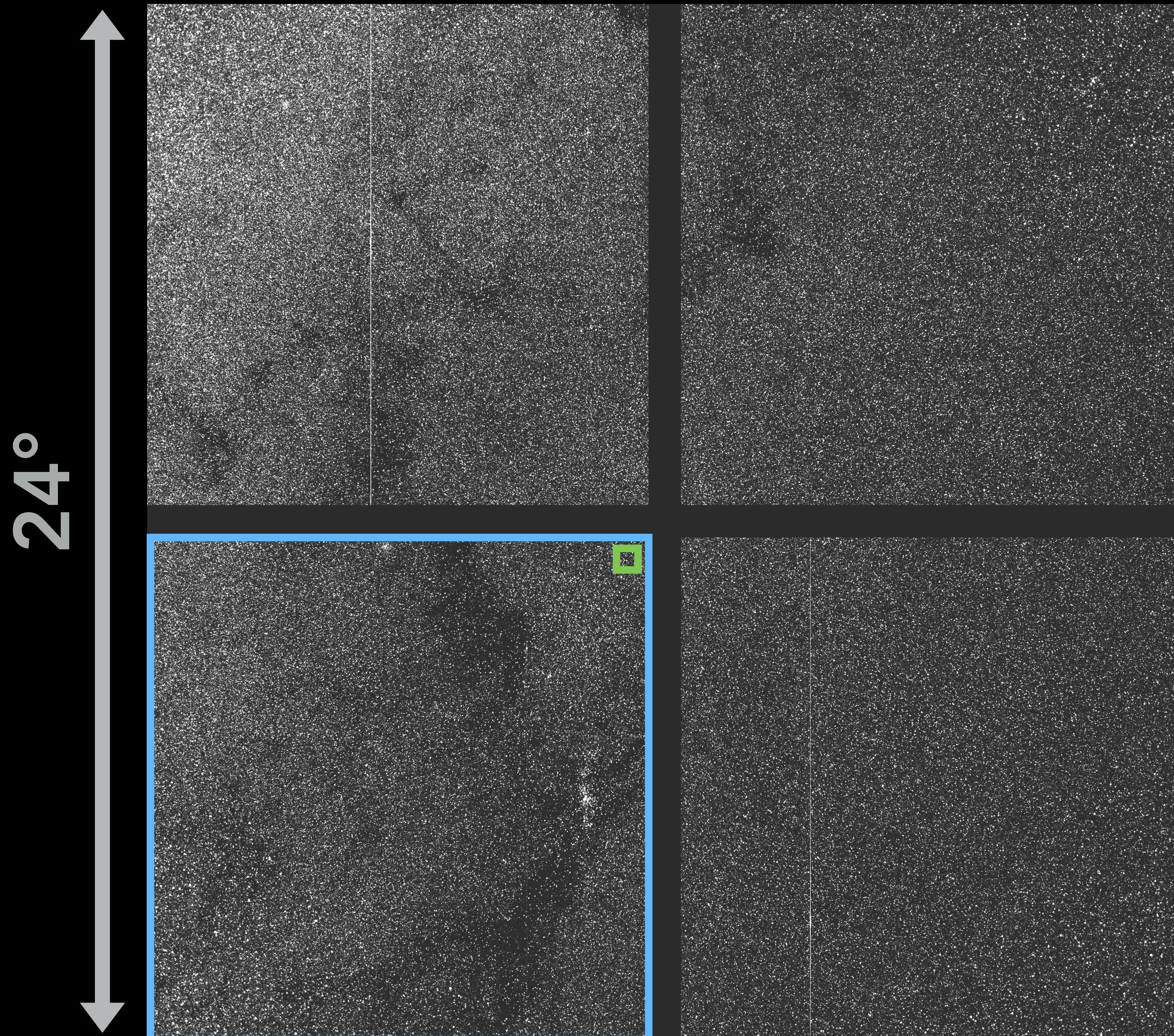
simulated images by Zach Berta-Thompson

TESS Slides from Zach Berta-Thompson



FOV from one TESS camera:

TESS Slides from
Zach Berta-Thompson



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FOV from one TESS camera:

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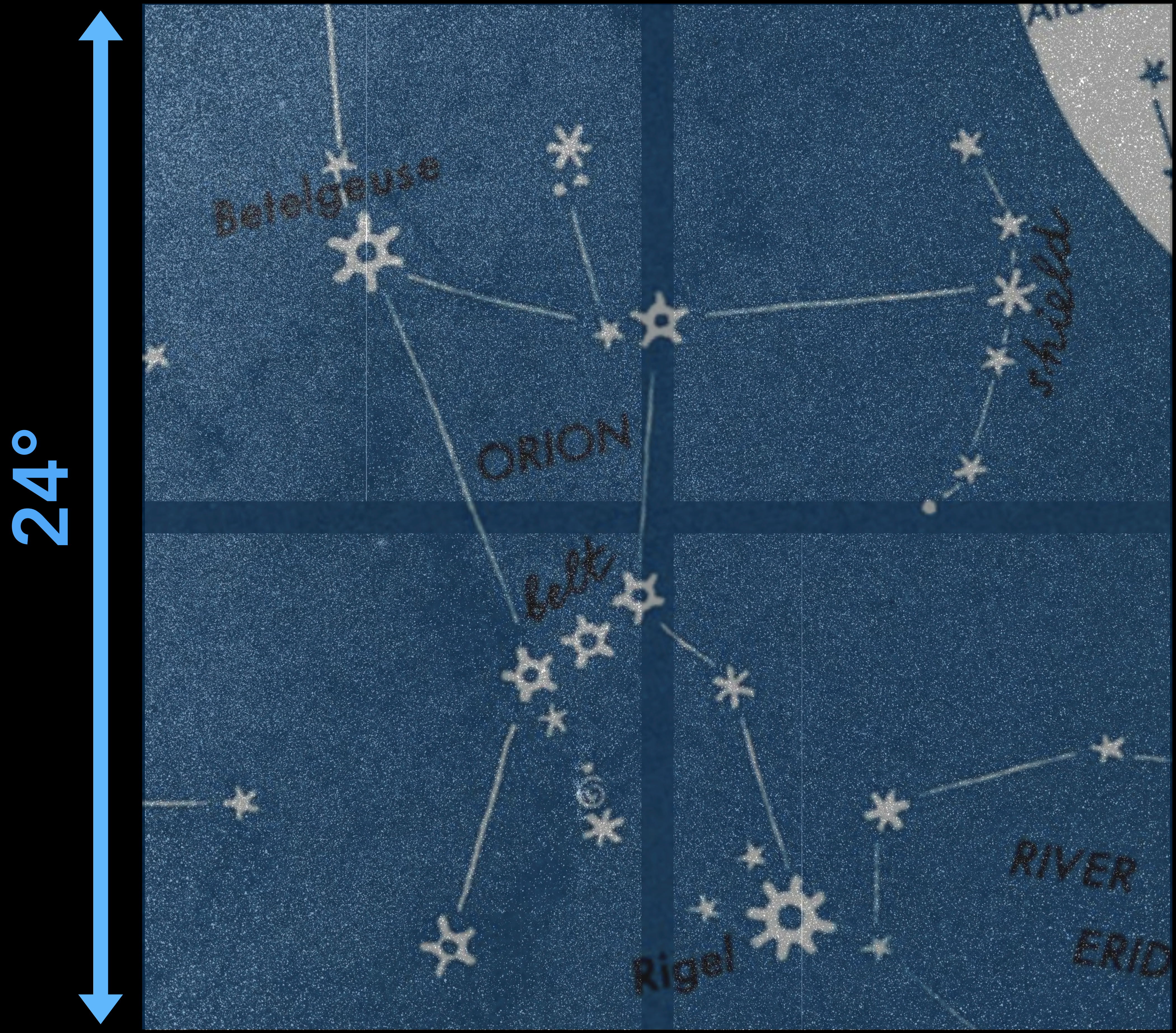
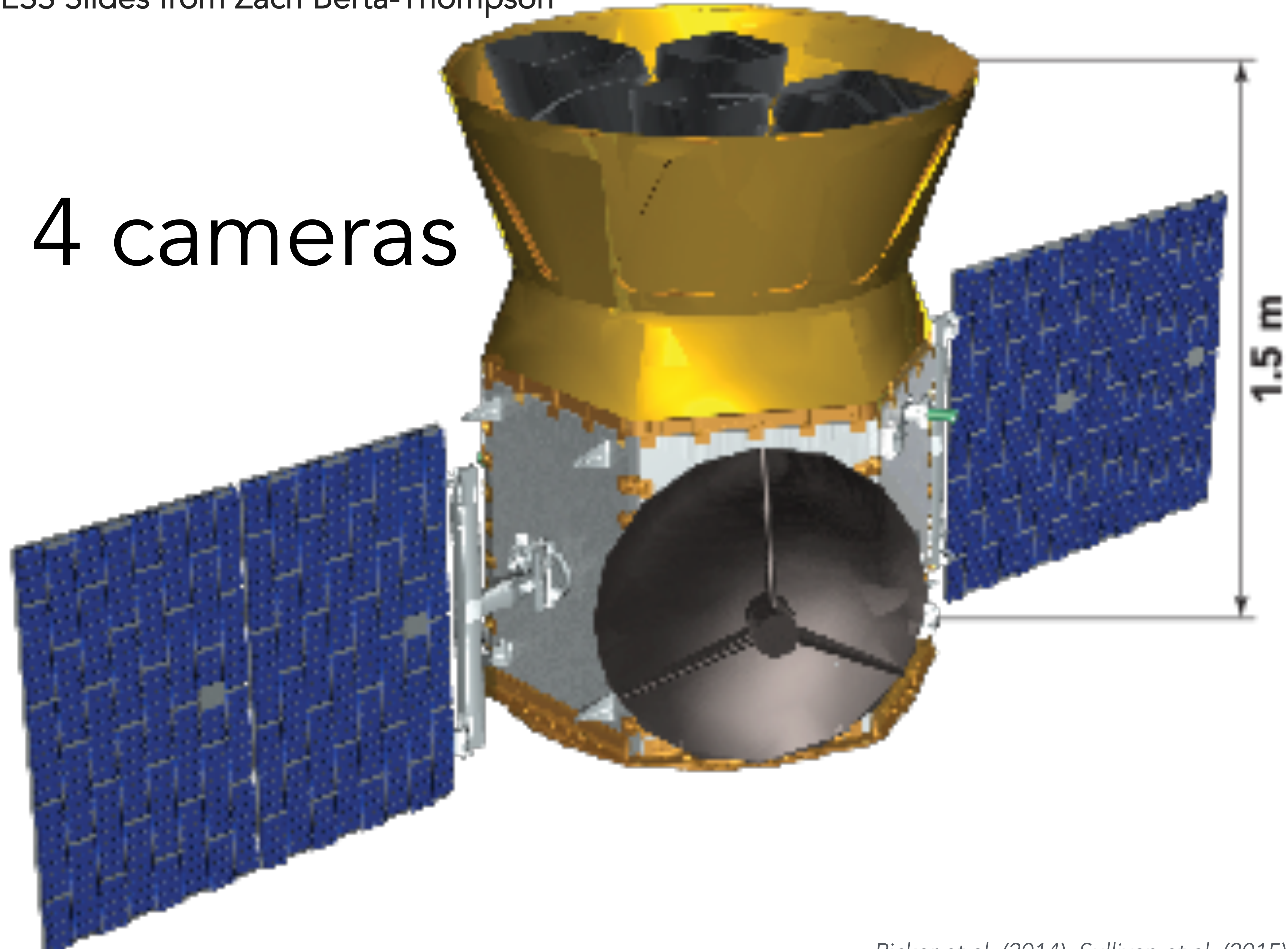


constellations by H. A. Rey

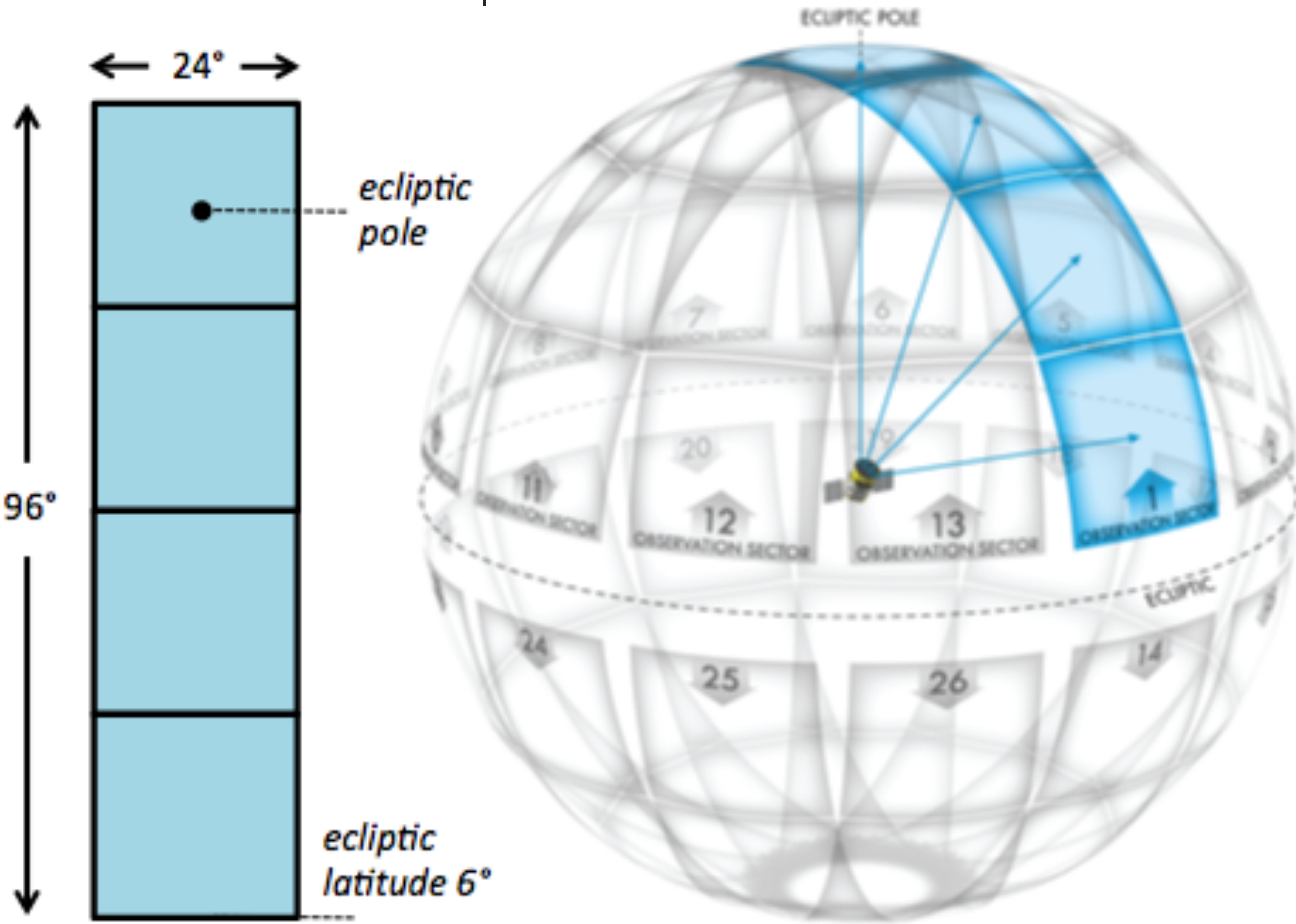
TESS Slides from Zach Berta-Thompson

4 cameras

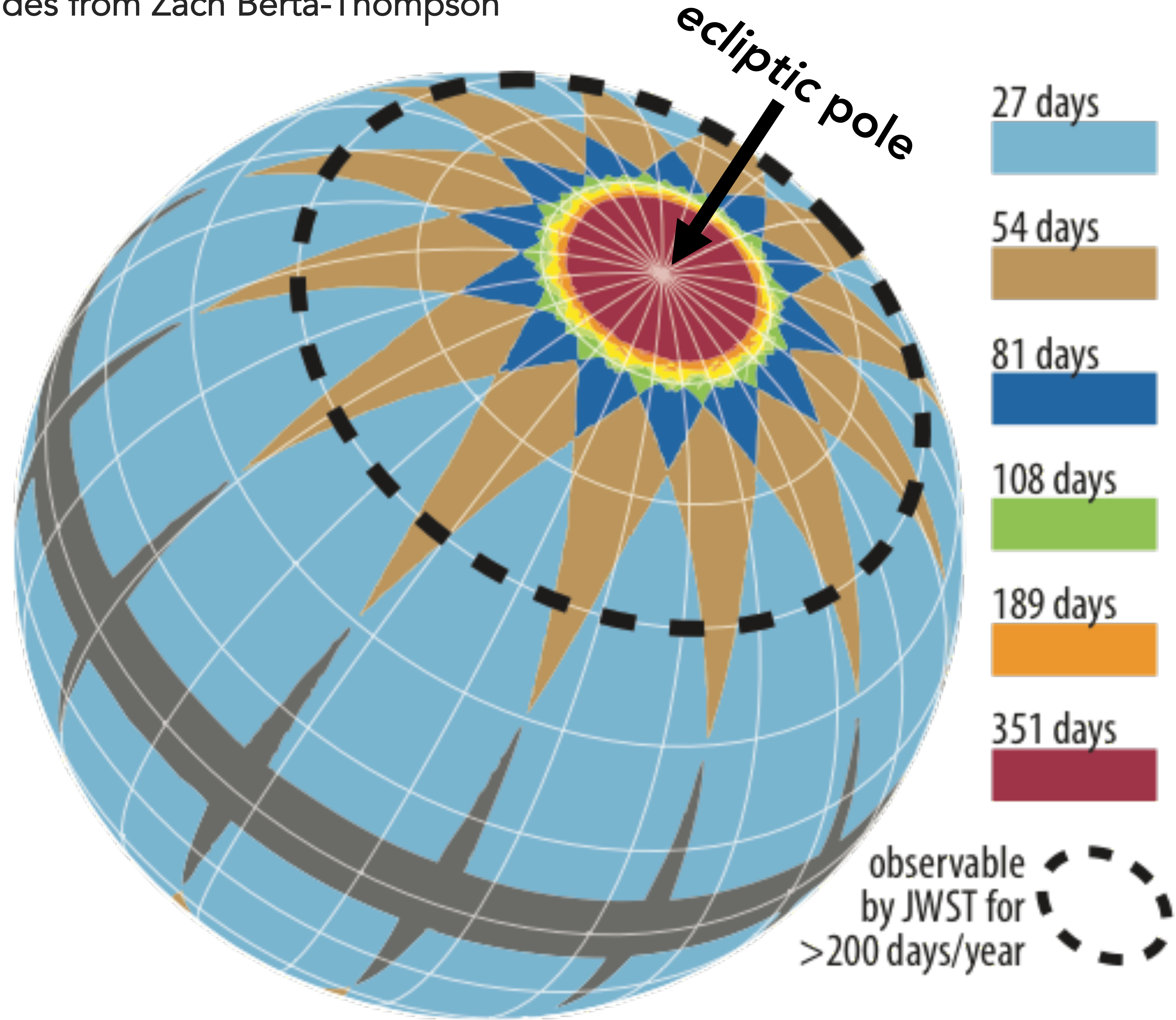


Ricker et al. (2014), Sullivan et al. (2015)

TESS Slides from Zach Berta-Thompson

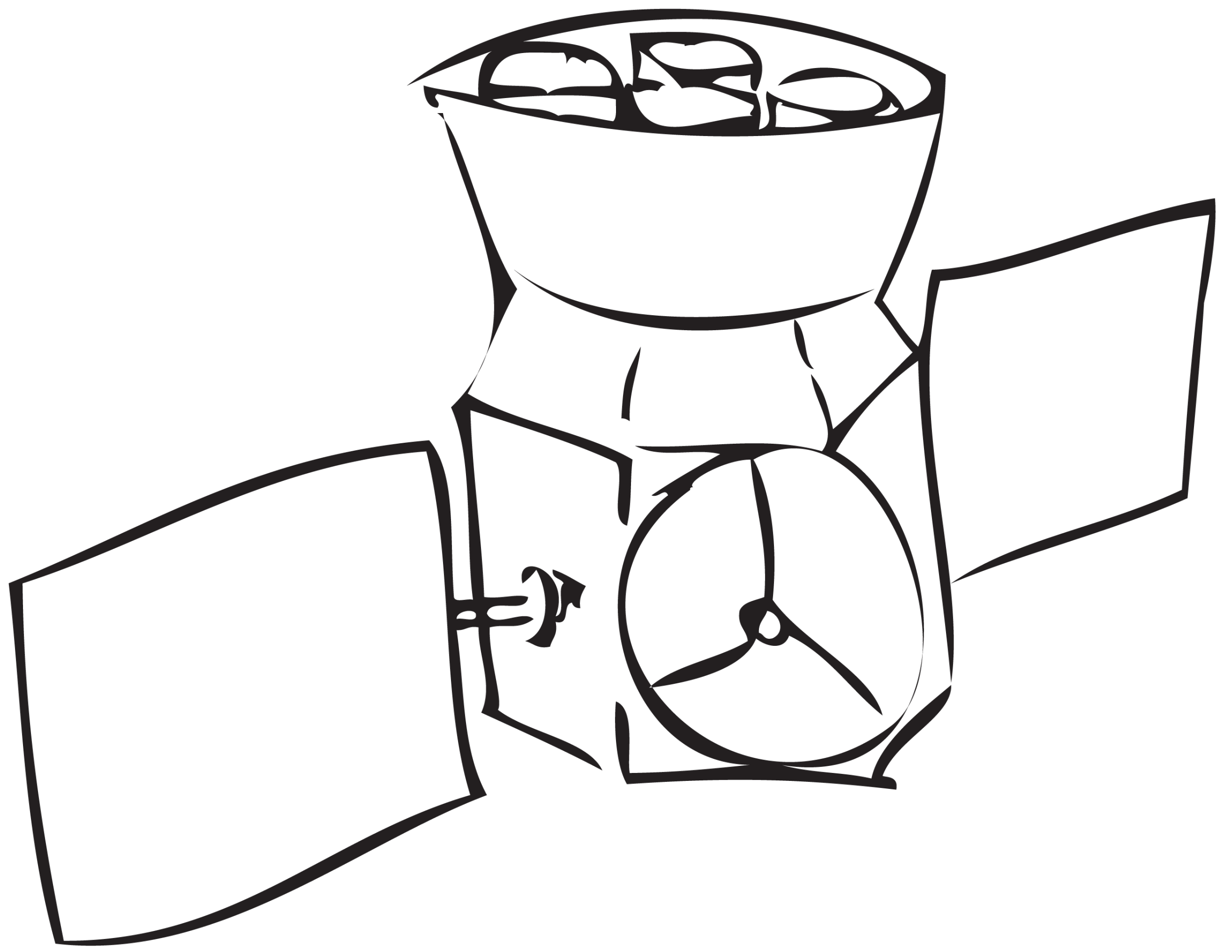


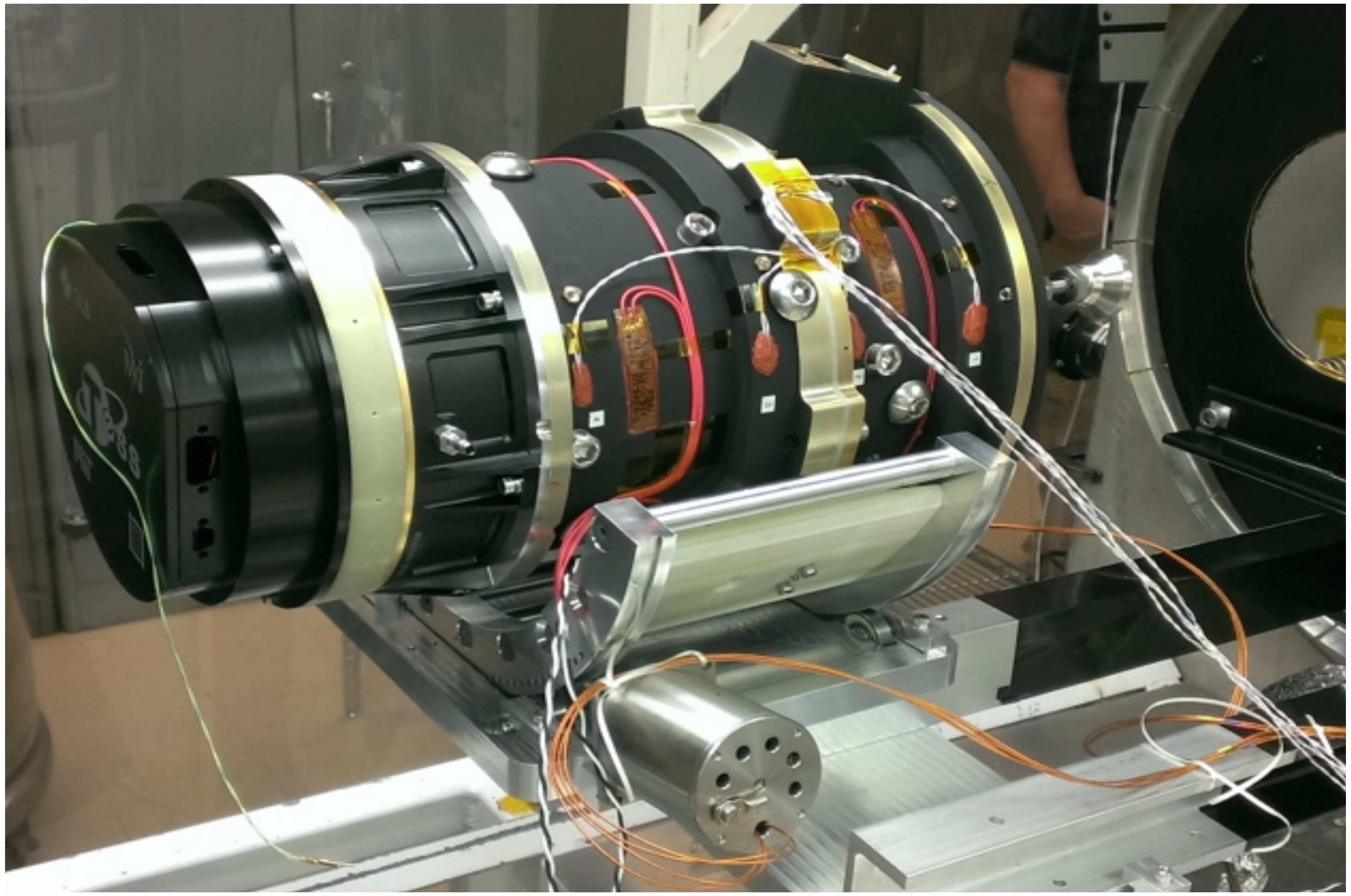
Ricker et al. (2014), Sullivan et al. (2015)

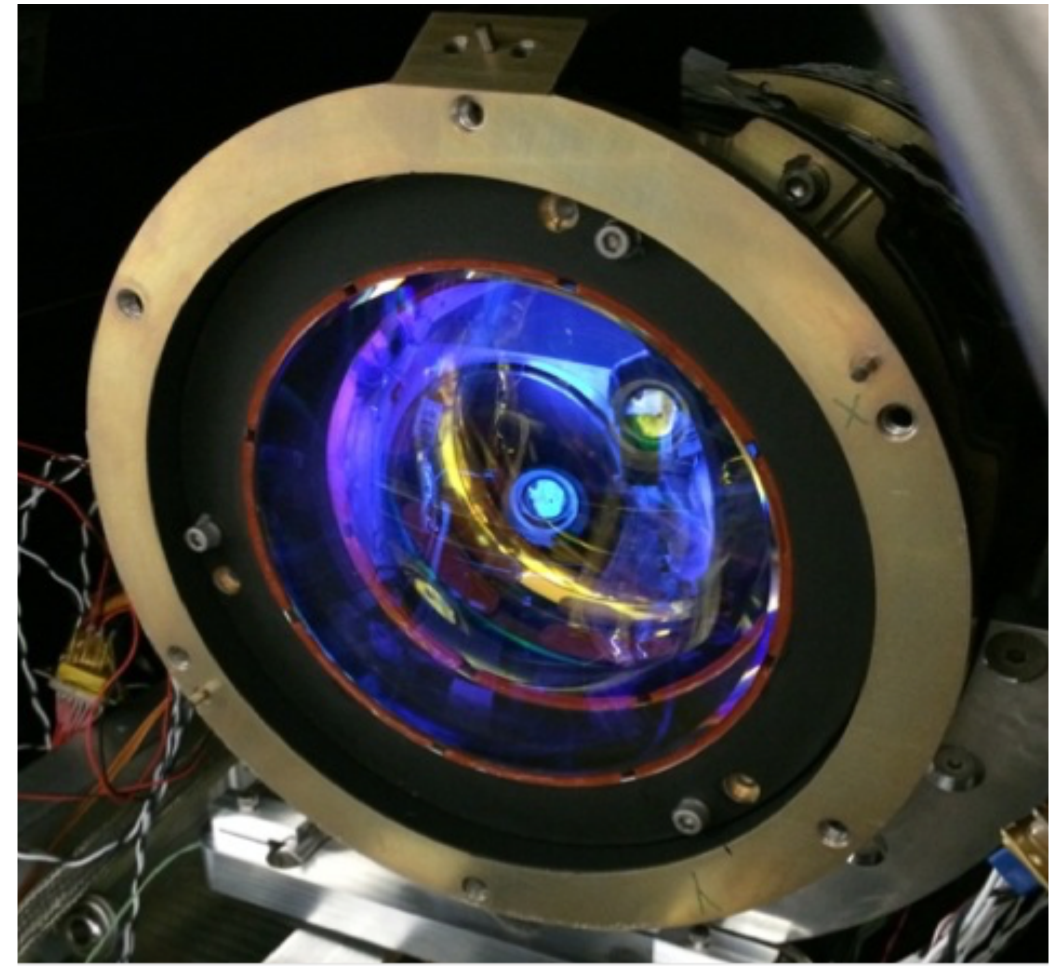


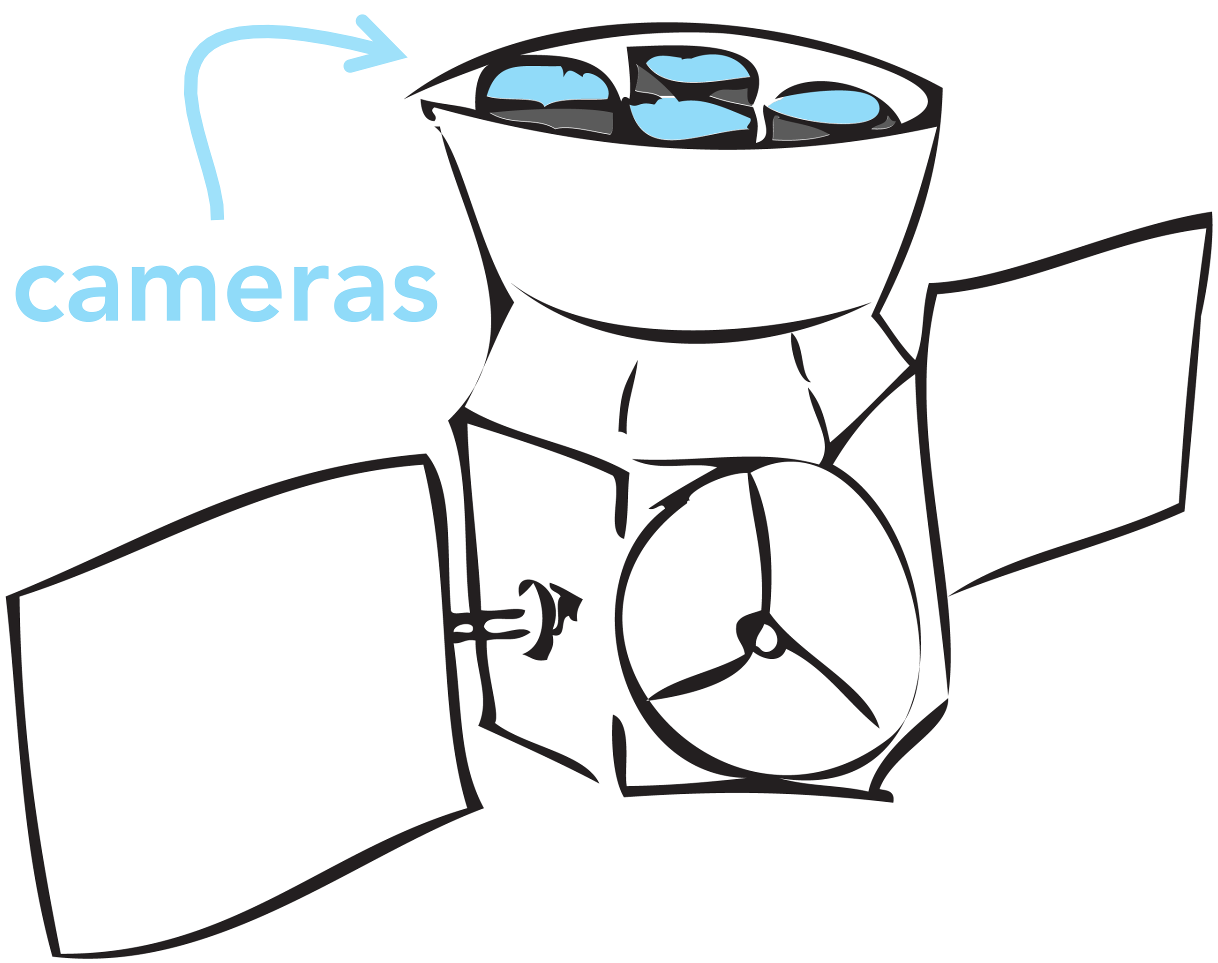
Ricker et al. (2014), Sullivan et al. (2015)

a brief tour of **TESS** hardware









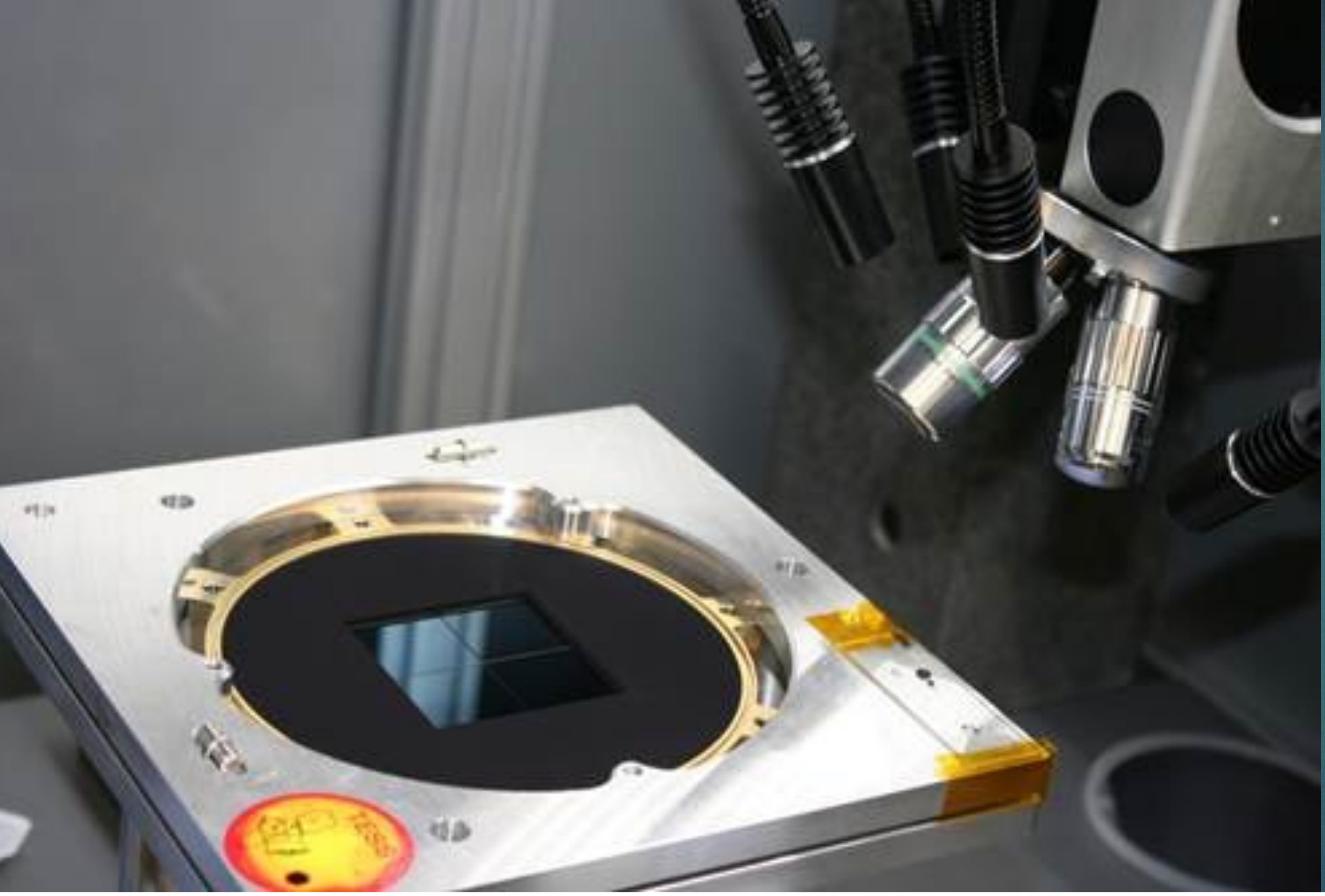
We built a complete TESS camera, for risk reduction and to develop test apparatuses.

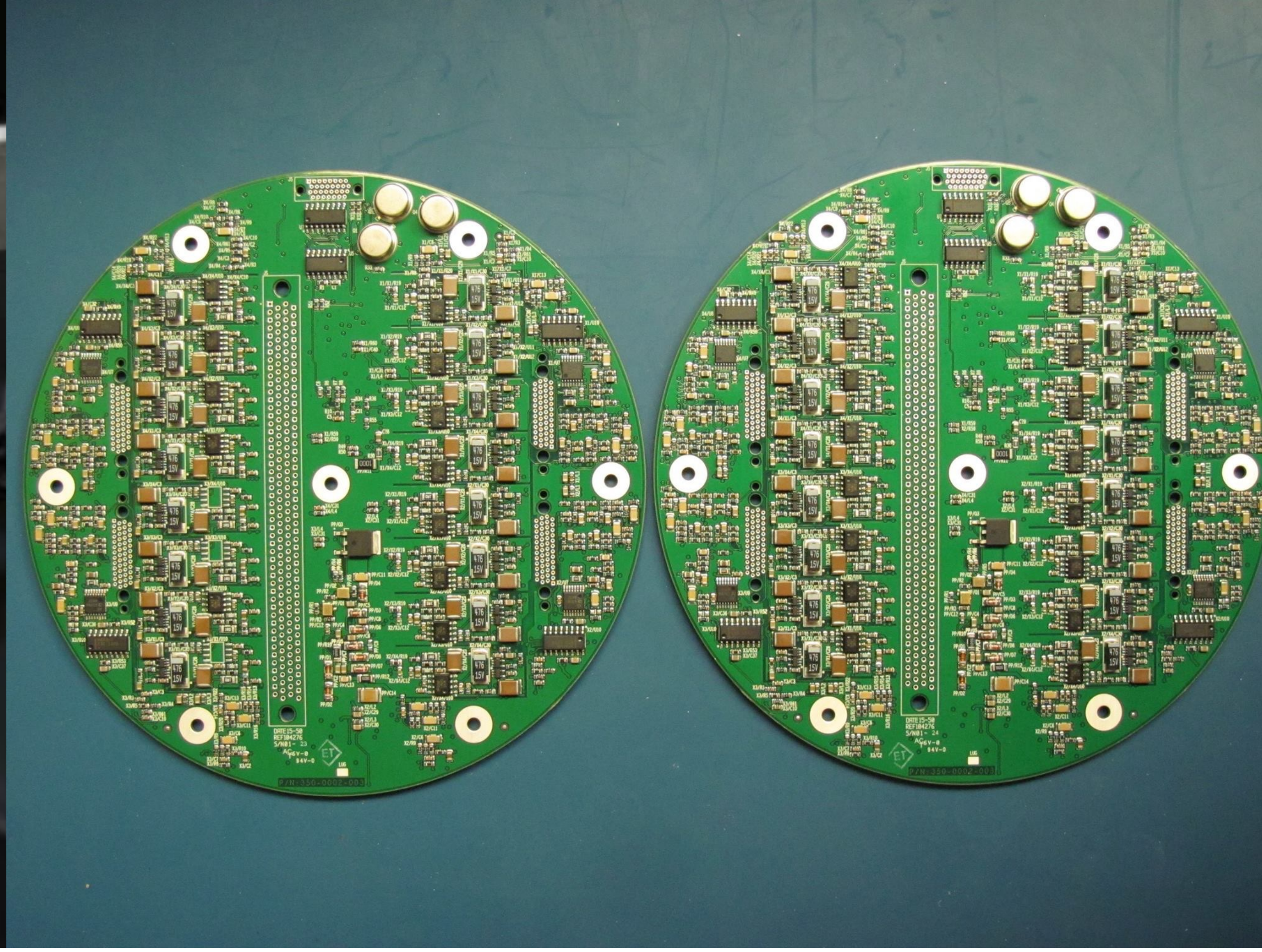
TESS Slides from Zach Berta-Thompson

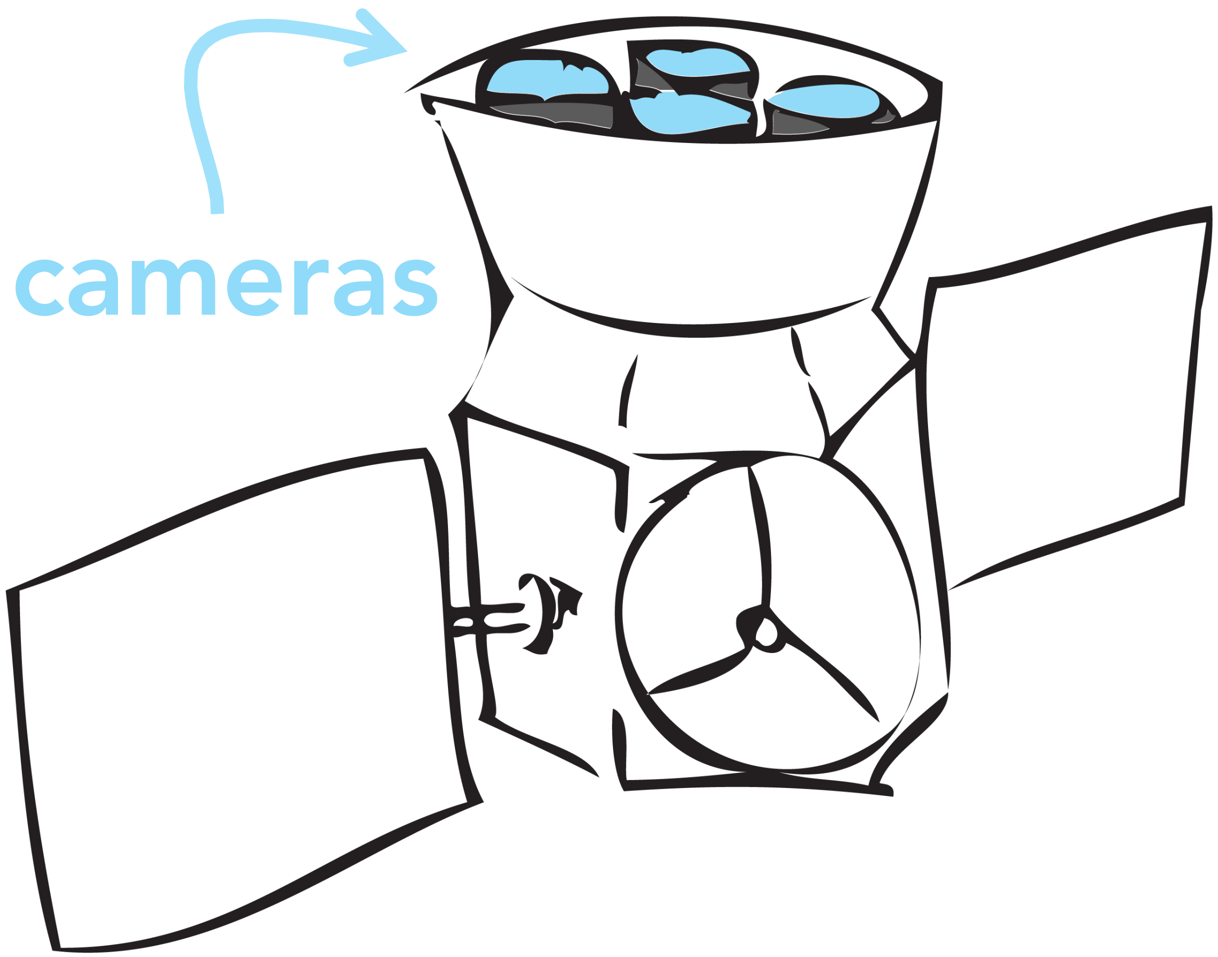
video from TESS camera *(at room temperature):*

Joel Villasenor, Carolyn Thayer, Tim Sauerwein

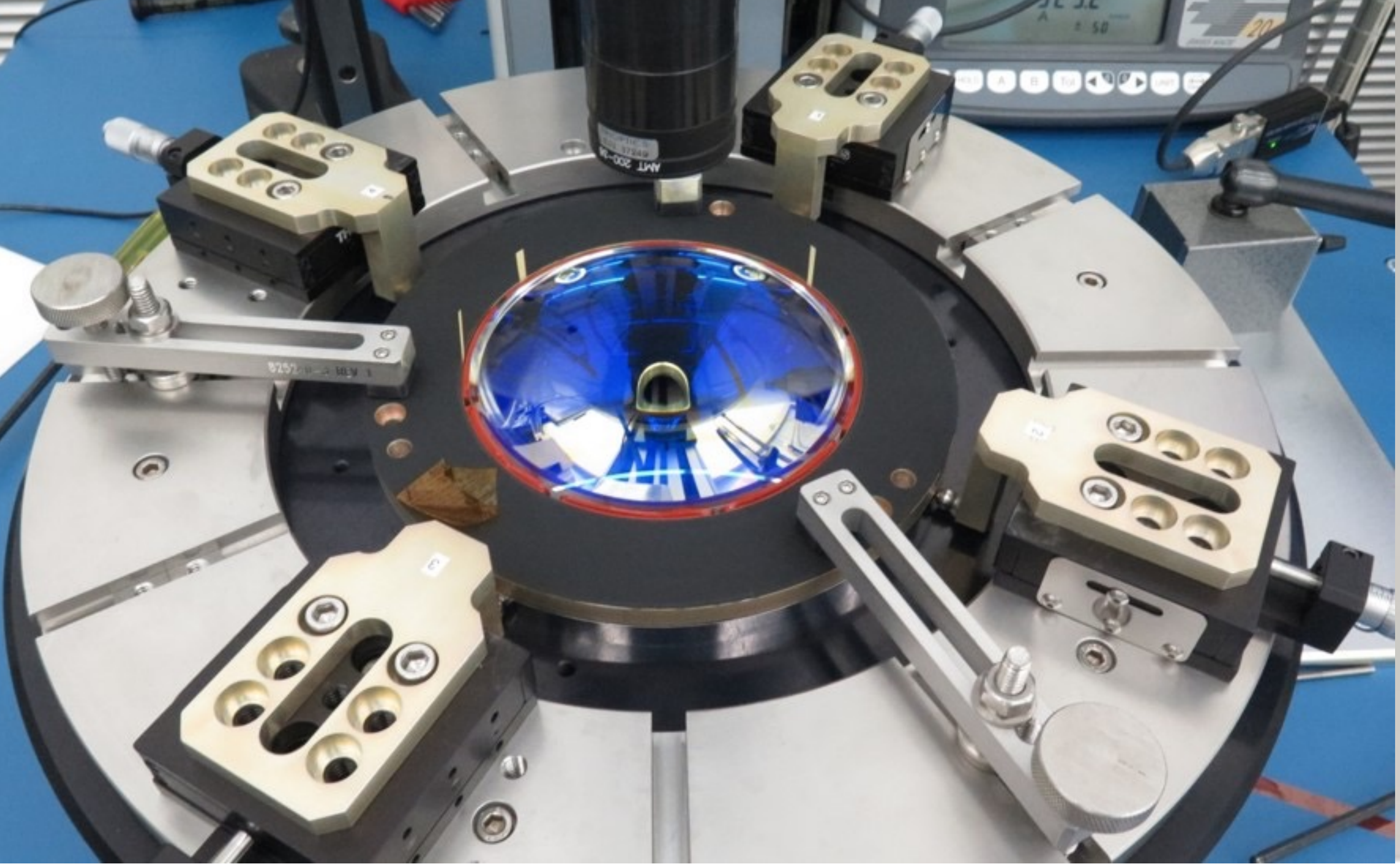
TESS Slides from Zach Berta-Thompson

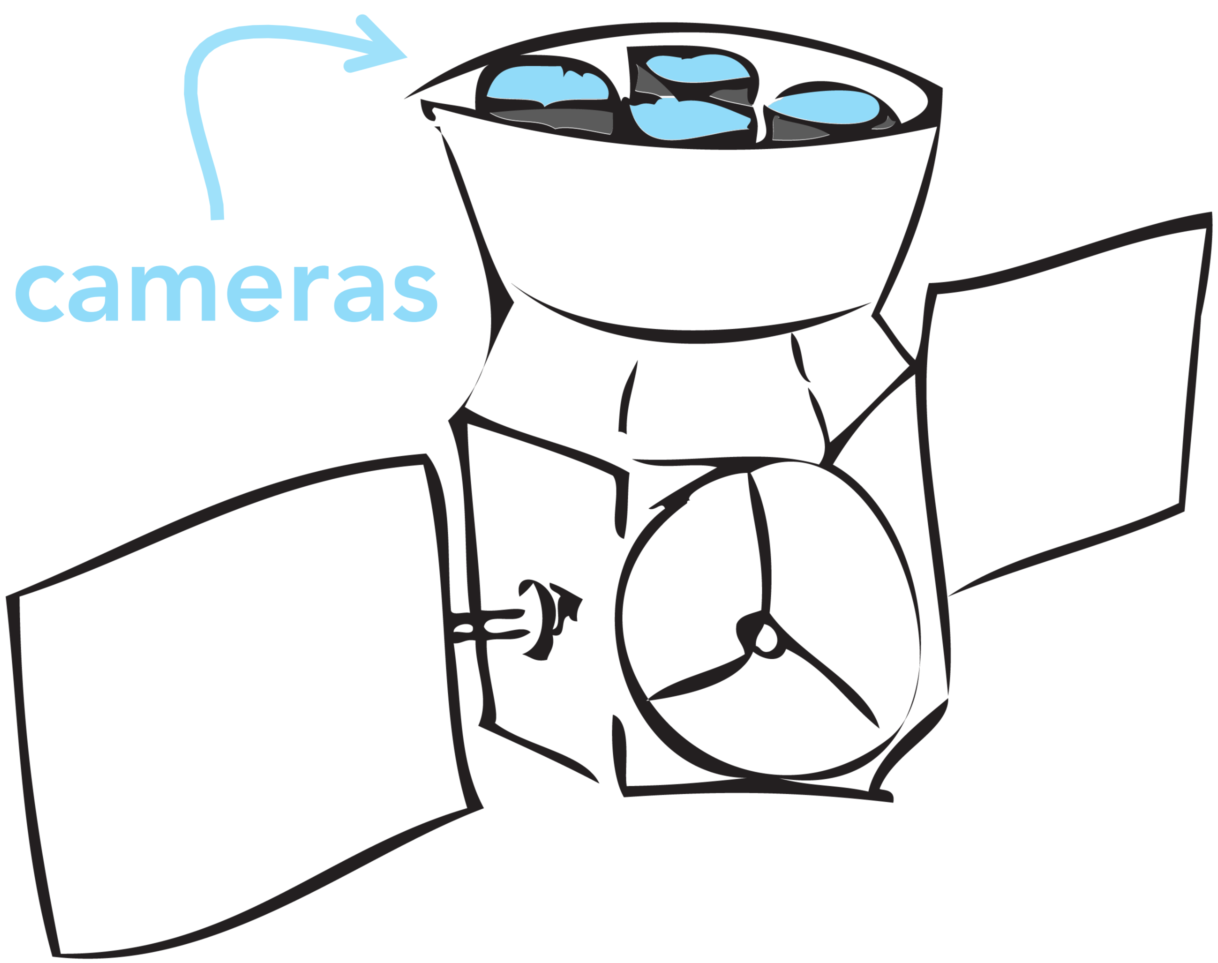






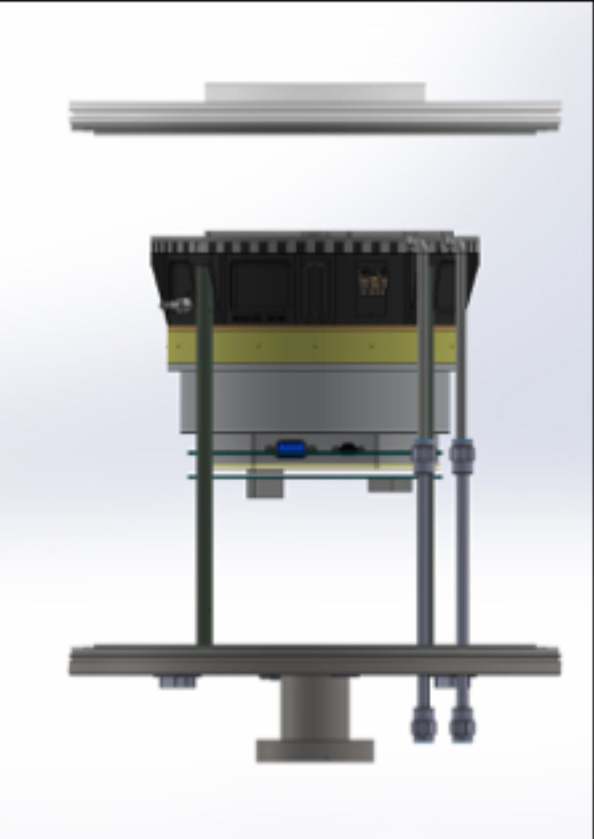
We are assembling flight CCDs and electronics.

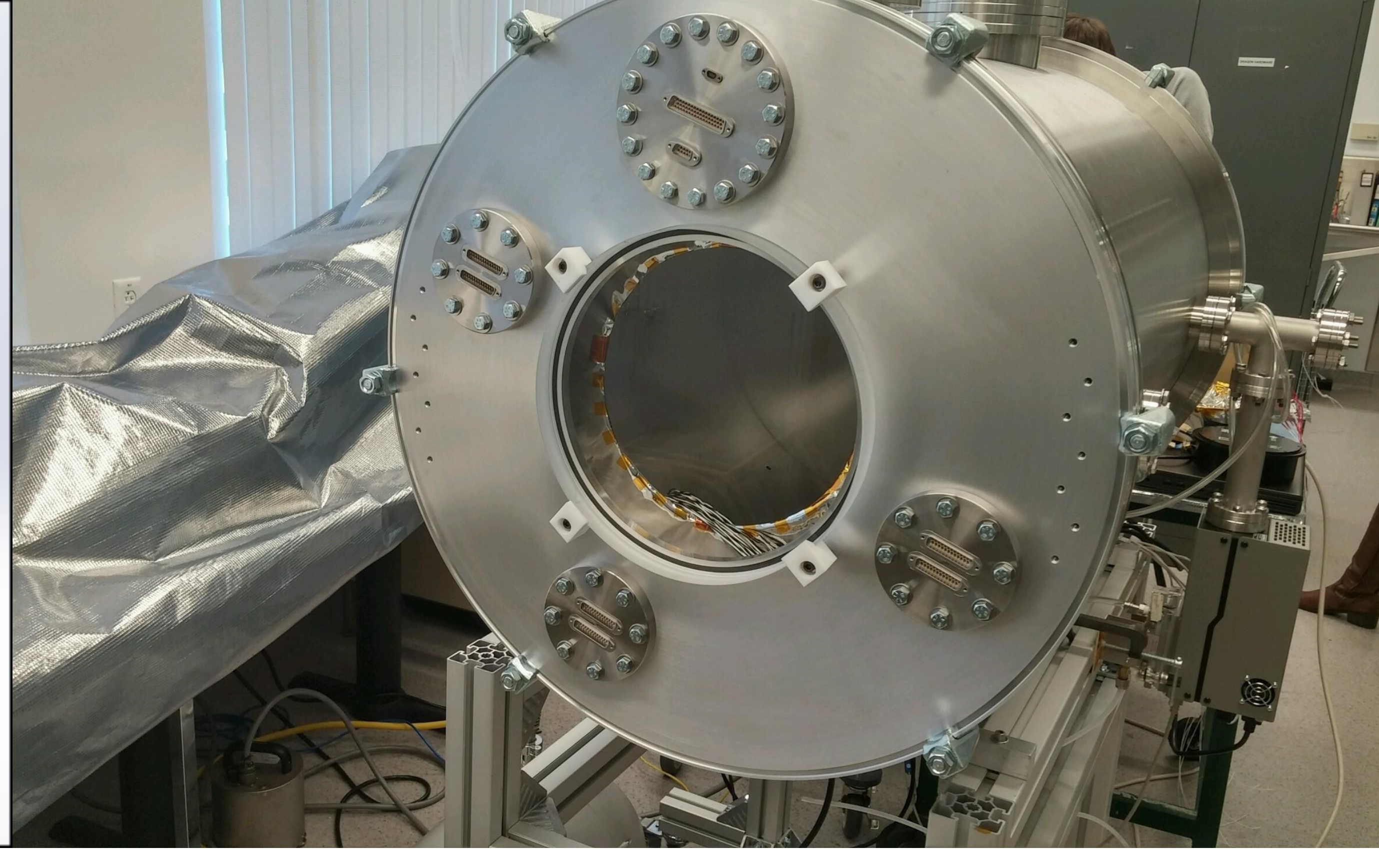


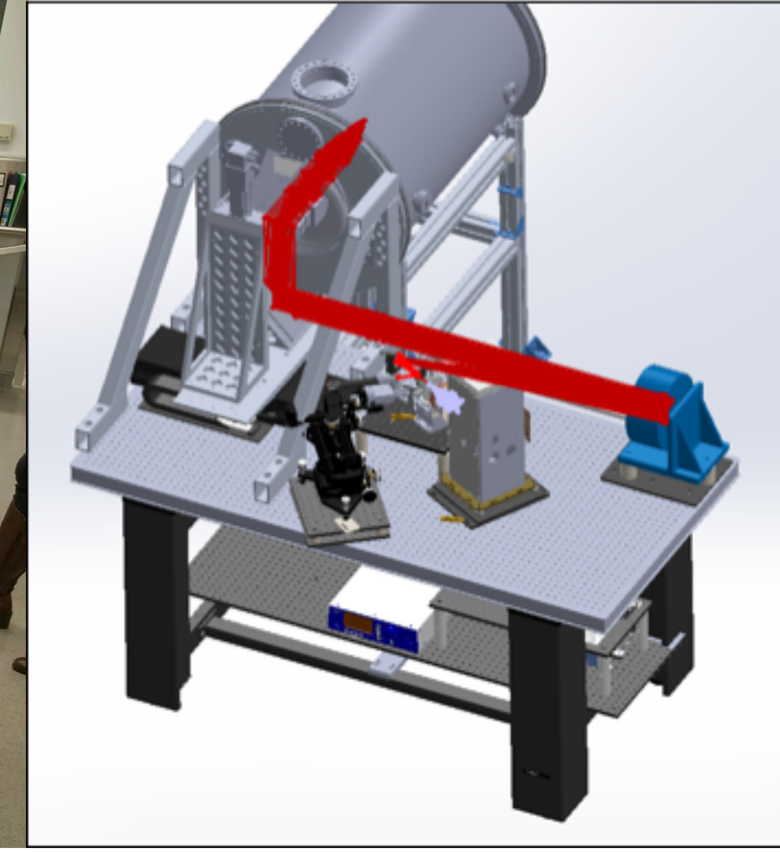


We are assembling flight lenses into cameras.

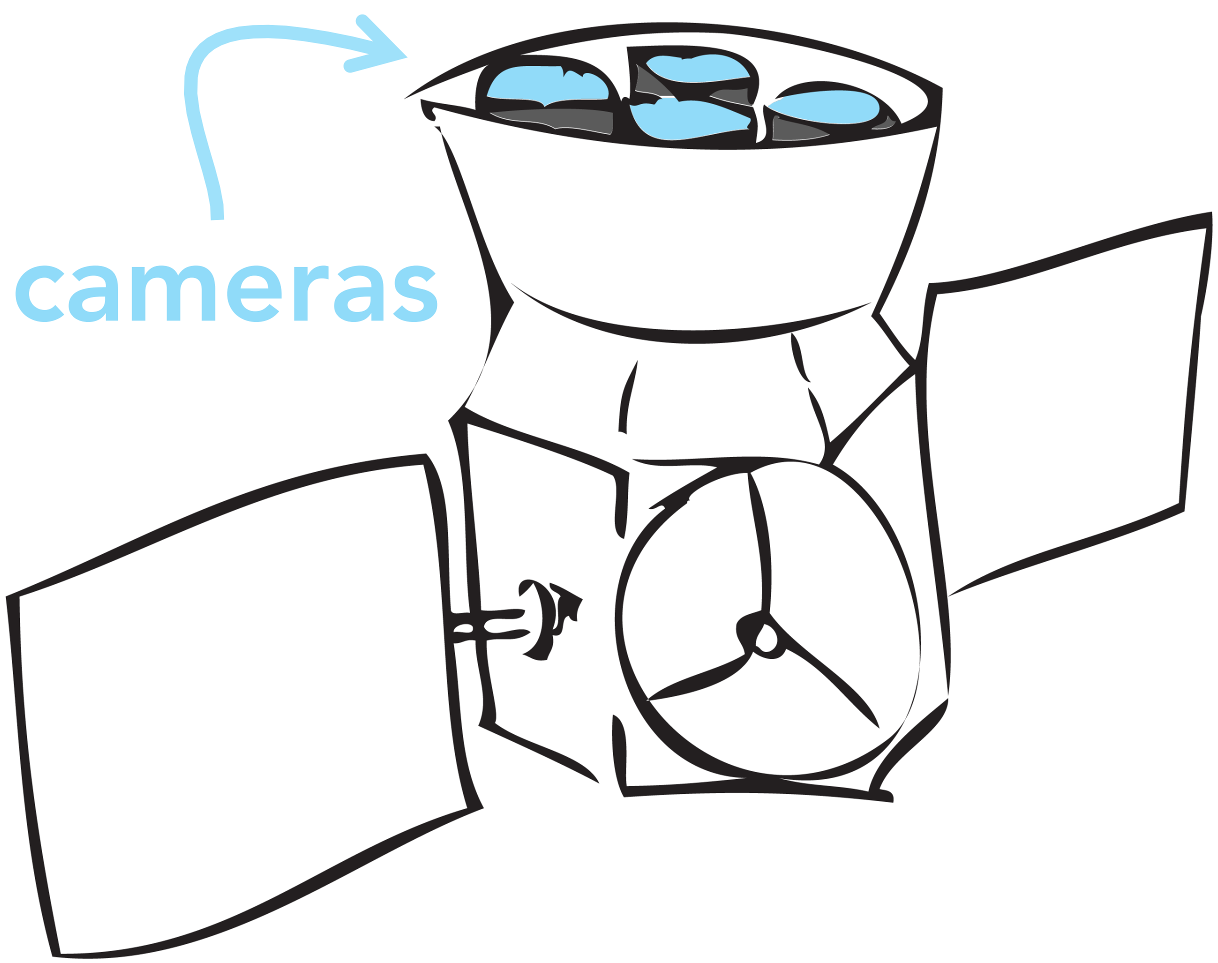
TESS Slides from Zach Berta-Thompson





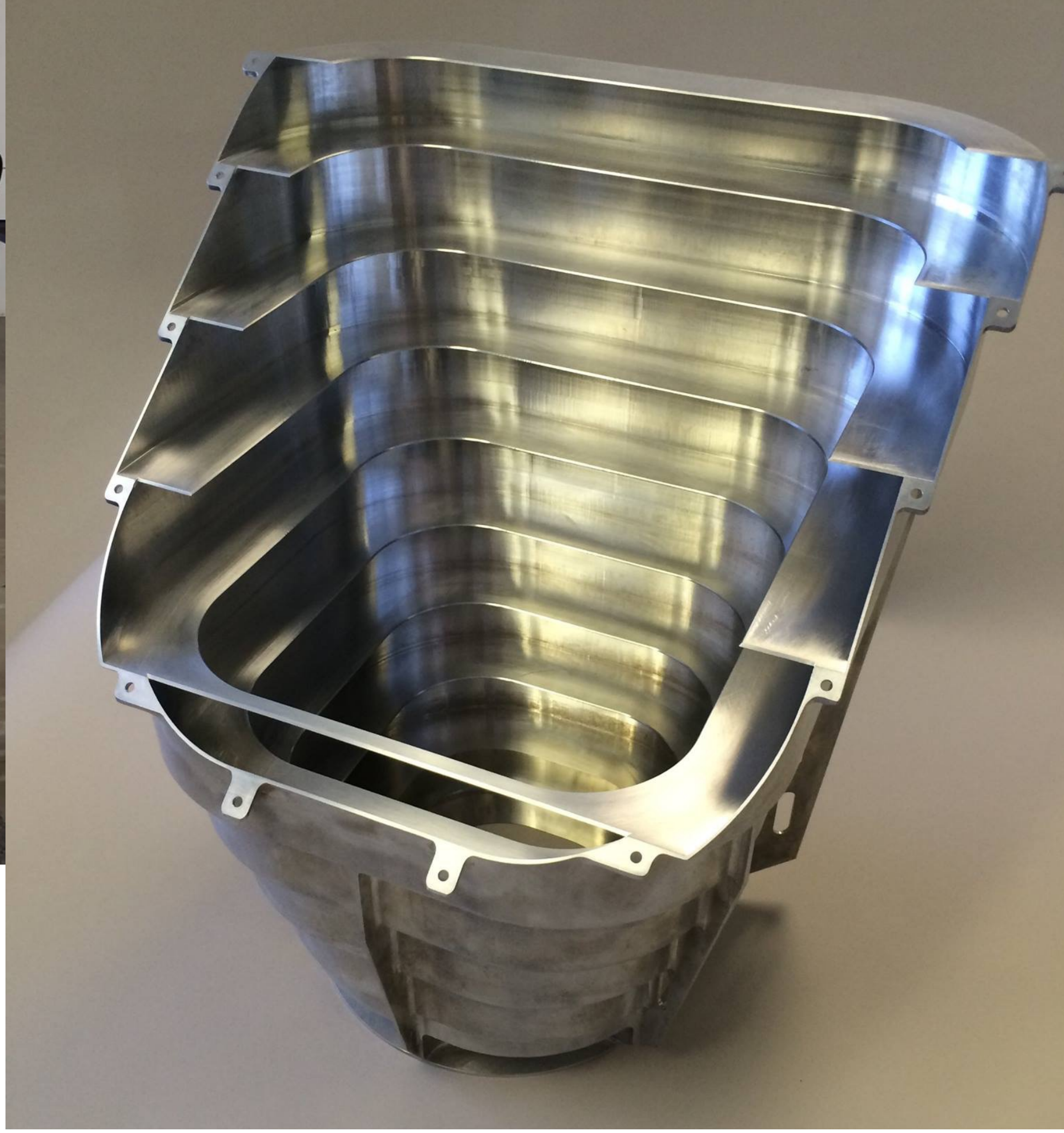


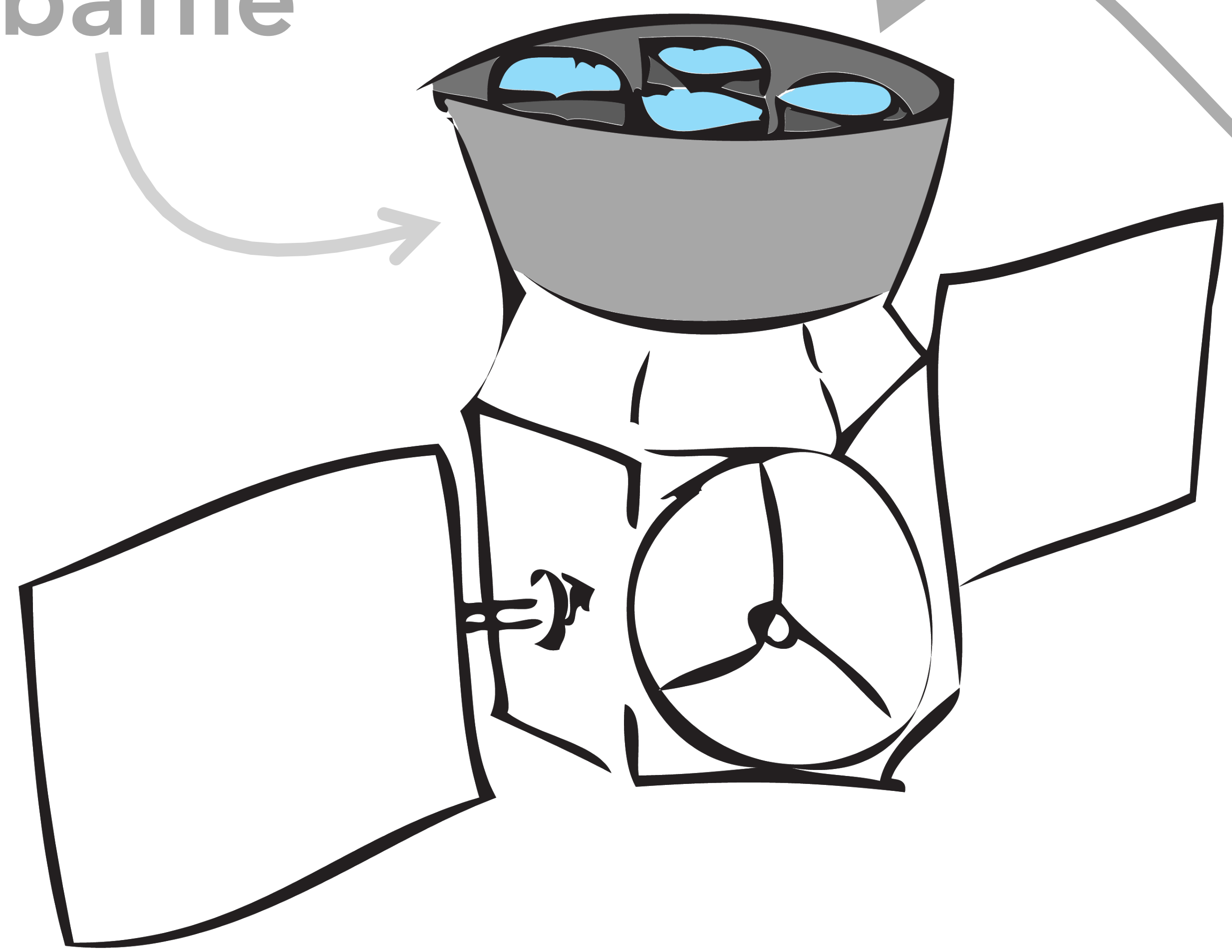
...& a superstable light source
(thanks CHEOPS!)



We built chambers and benches to characterize detector packages and complete cameras

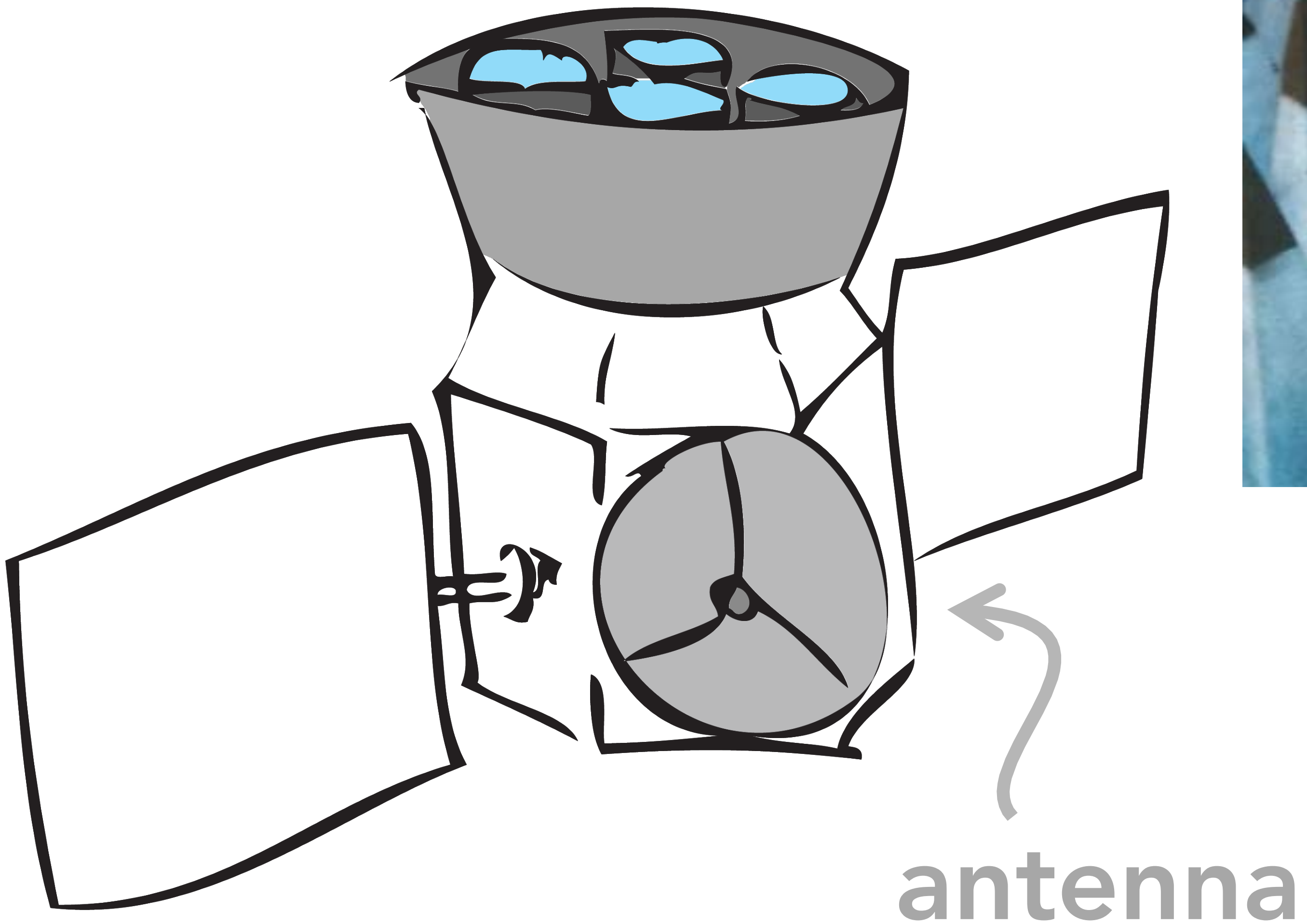
(gain, linearity, flat-field, quantum efficiency, focus).

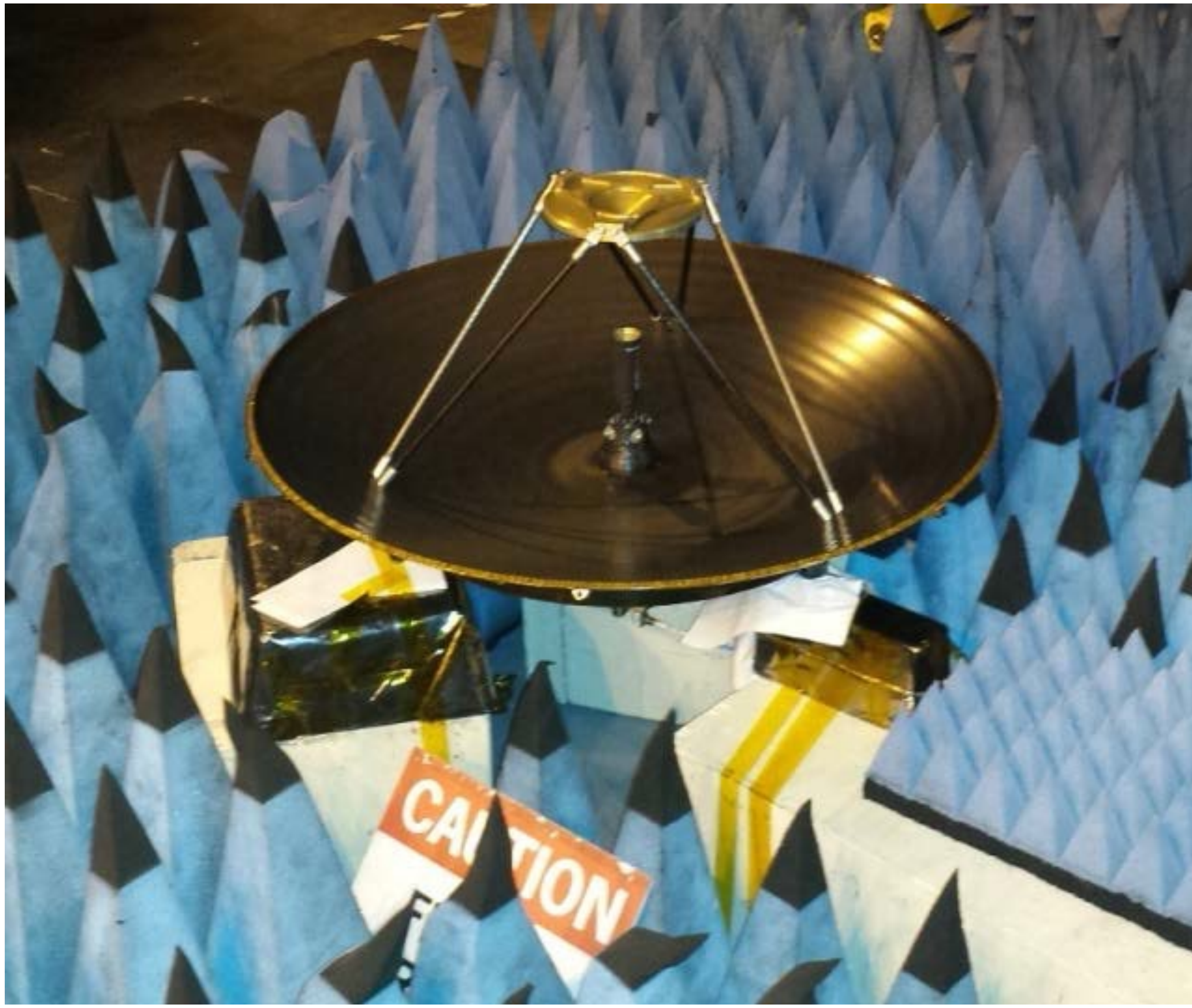


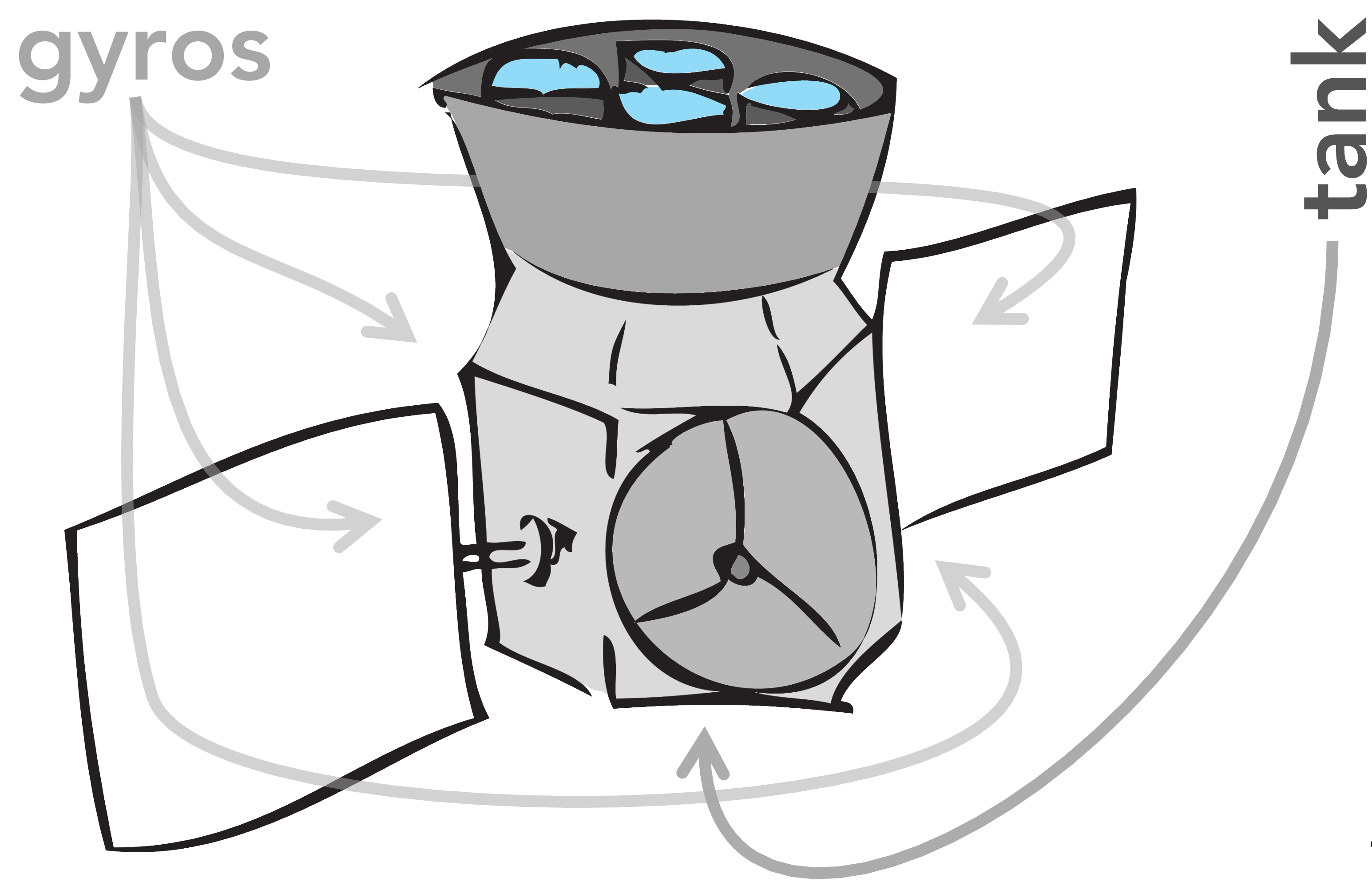


The flight sunshade baffle is made, and lens hoods are underway.

The high gain antenna has been built and tested.



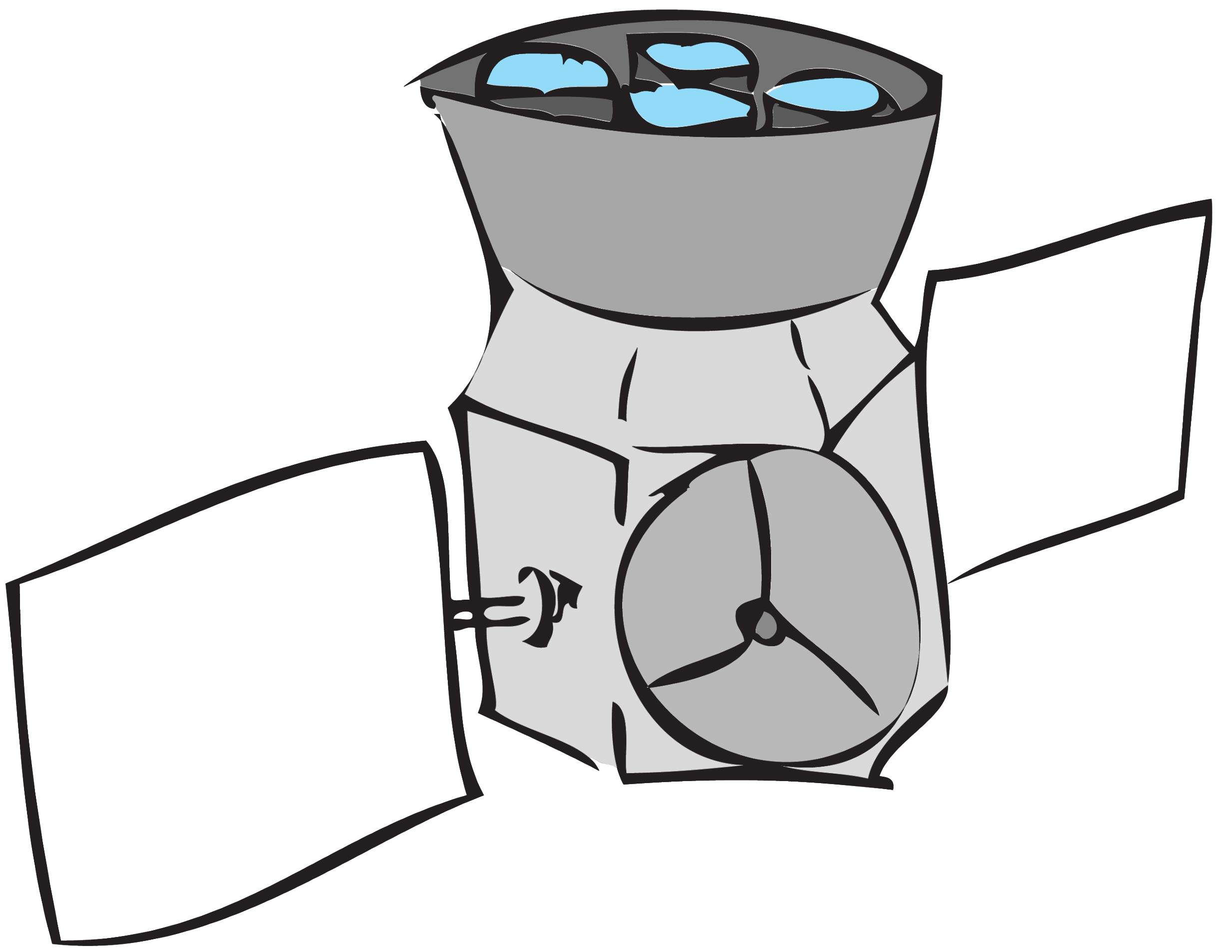


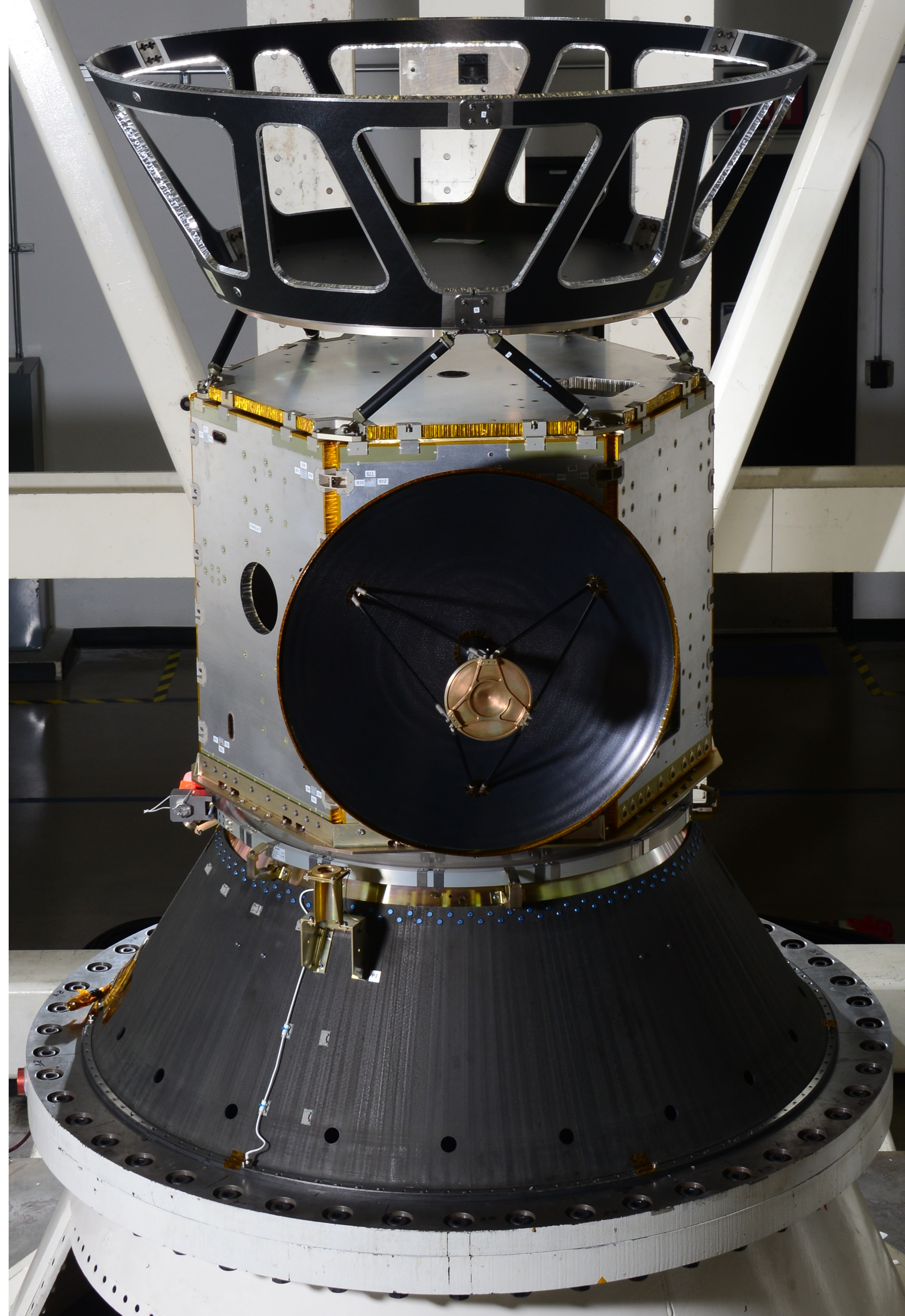


The flight reaction wheels and propellent tank exist.

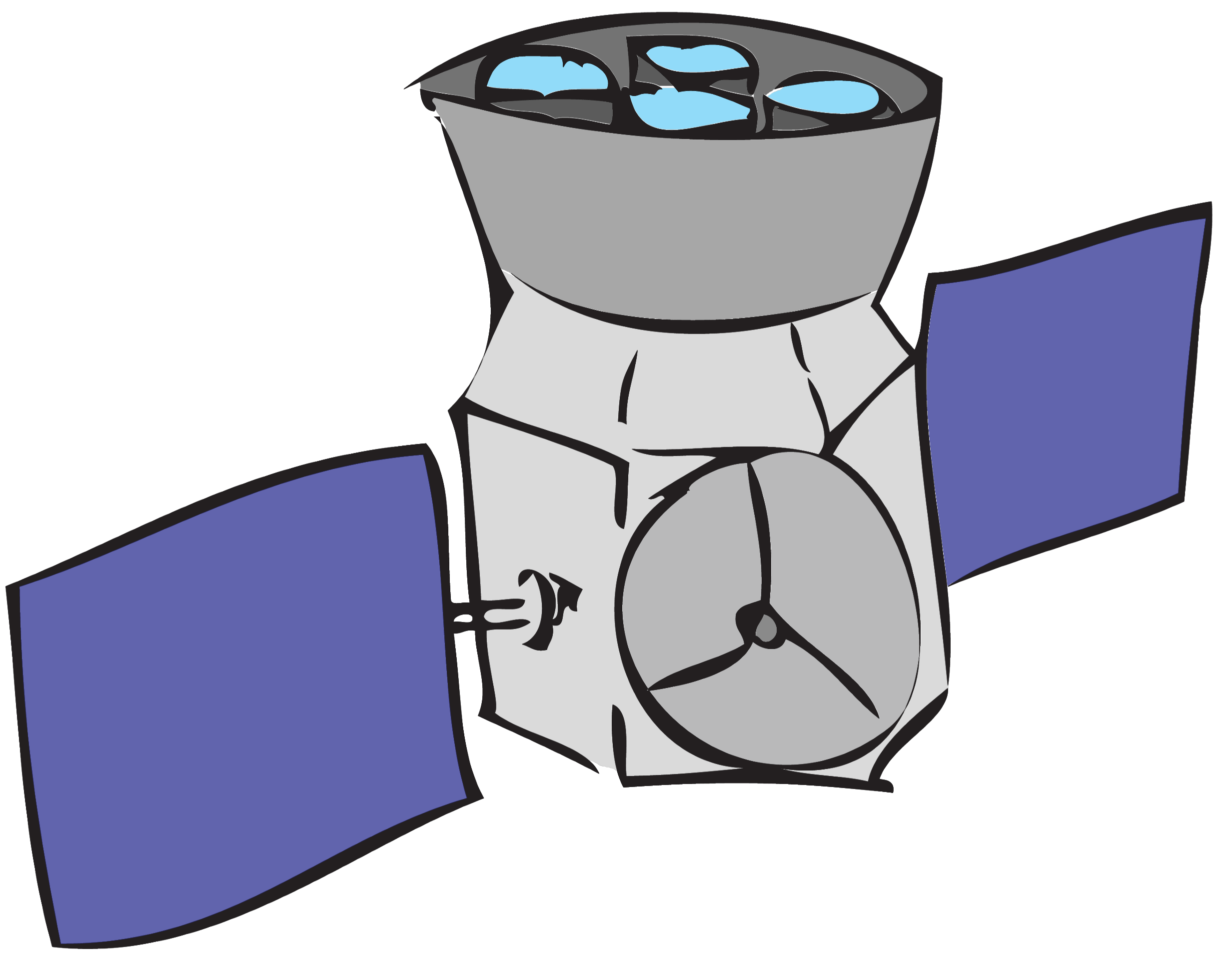
TESS Slides from Zach Berta-Thompson

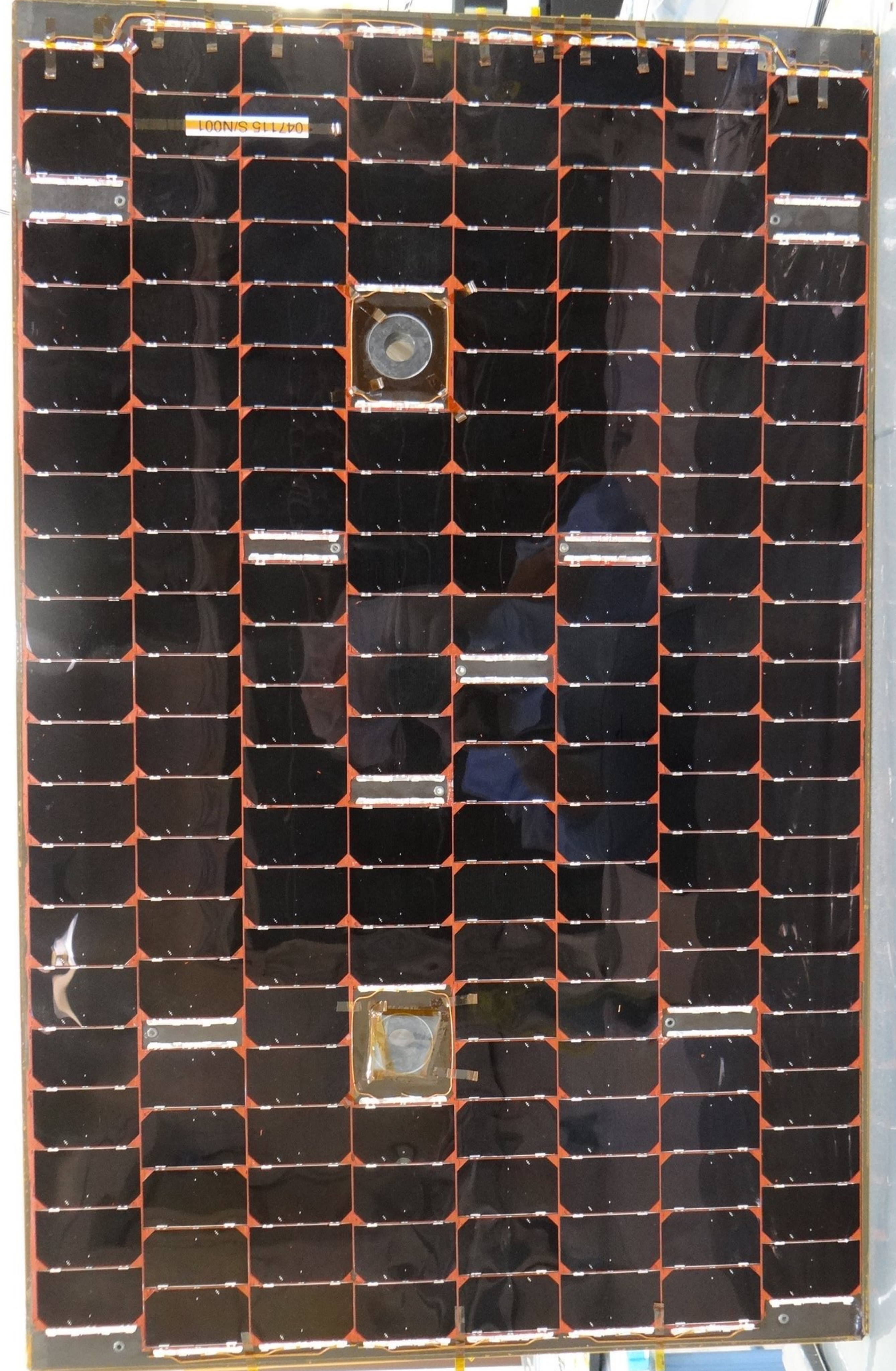
The primary structure has been tested on the rocket interface cone.



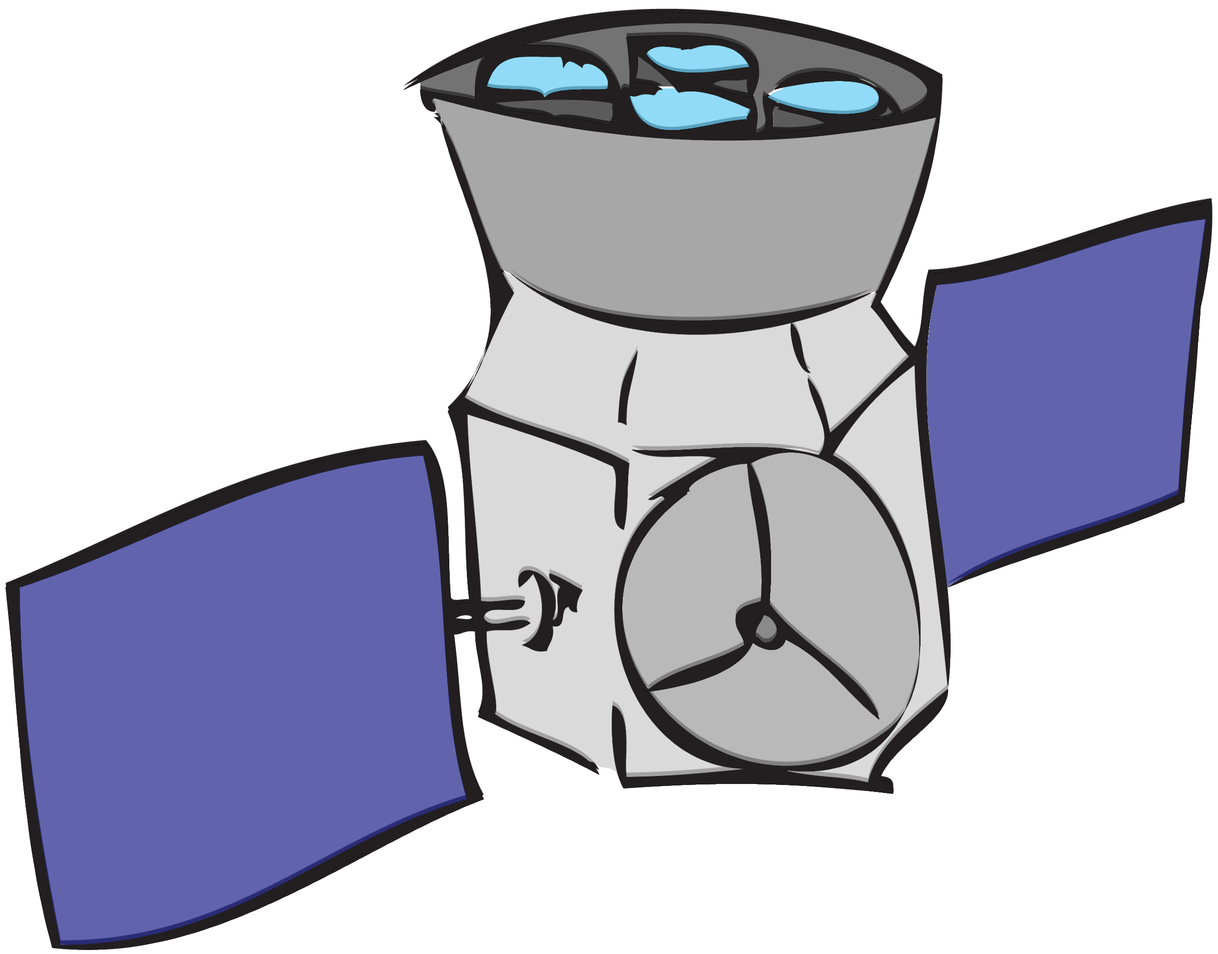


Flight solar panels
are being built.





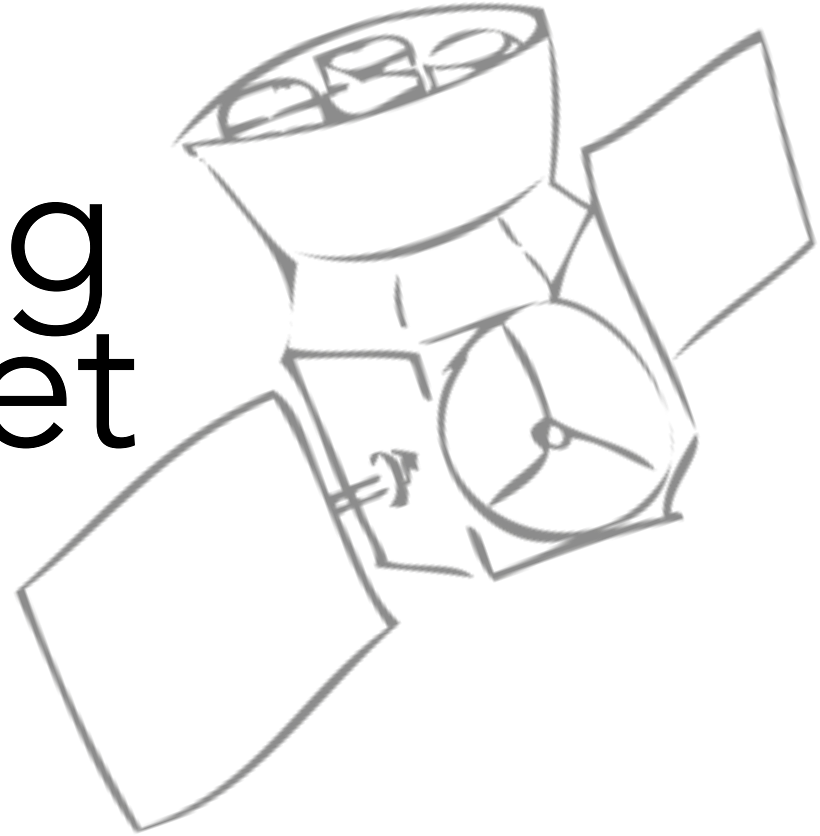
TESS is happening!



TESS Slides from Zach Berta-Thompson

TESS Slides from
Zach Berta-Thompson

Transiting Exoplanet Survey Satellite

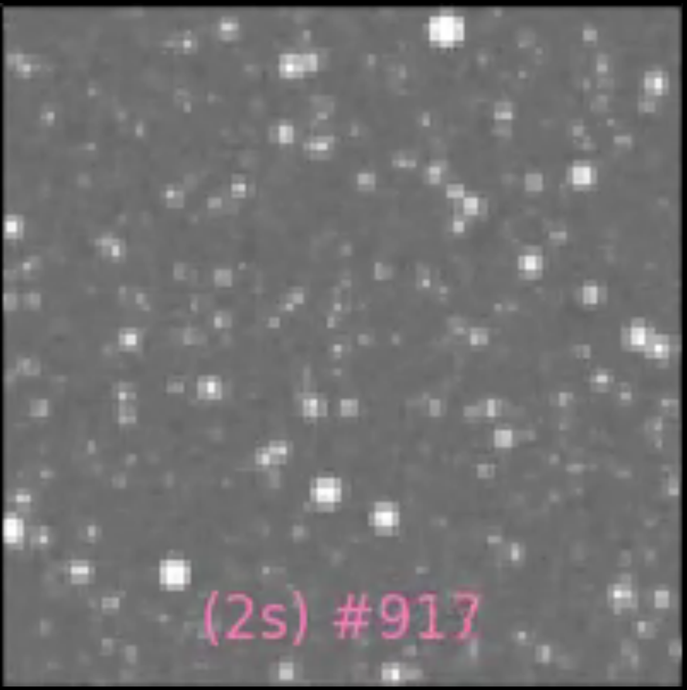


Why do we need it?
How will it work?
What data will it collect?
When should you care?

TESS Slides from Zach Berta-Thompson

0.5°

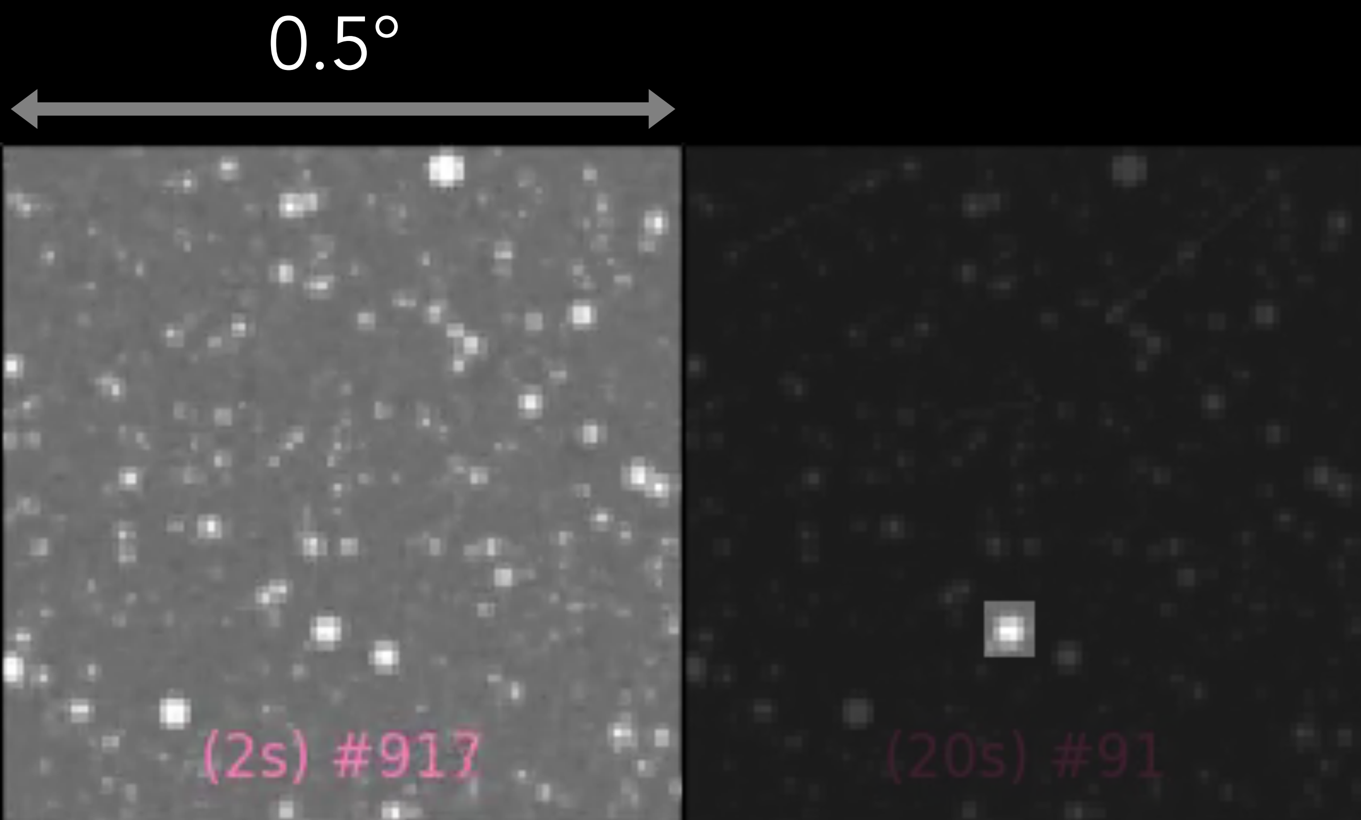
(60X speed)



The TESS CCDs take **2 second** exposures. These data are used for guiding, but not downloaded.

TESS Slides from Zach Berta-Thompson

(60X speed)

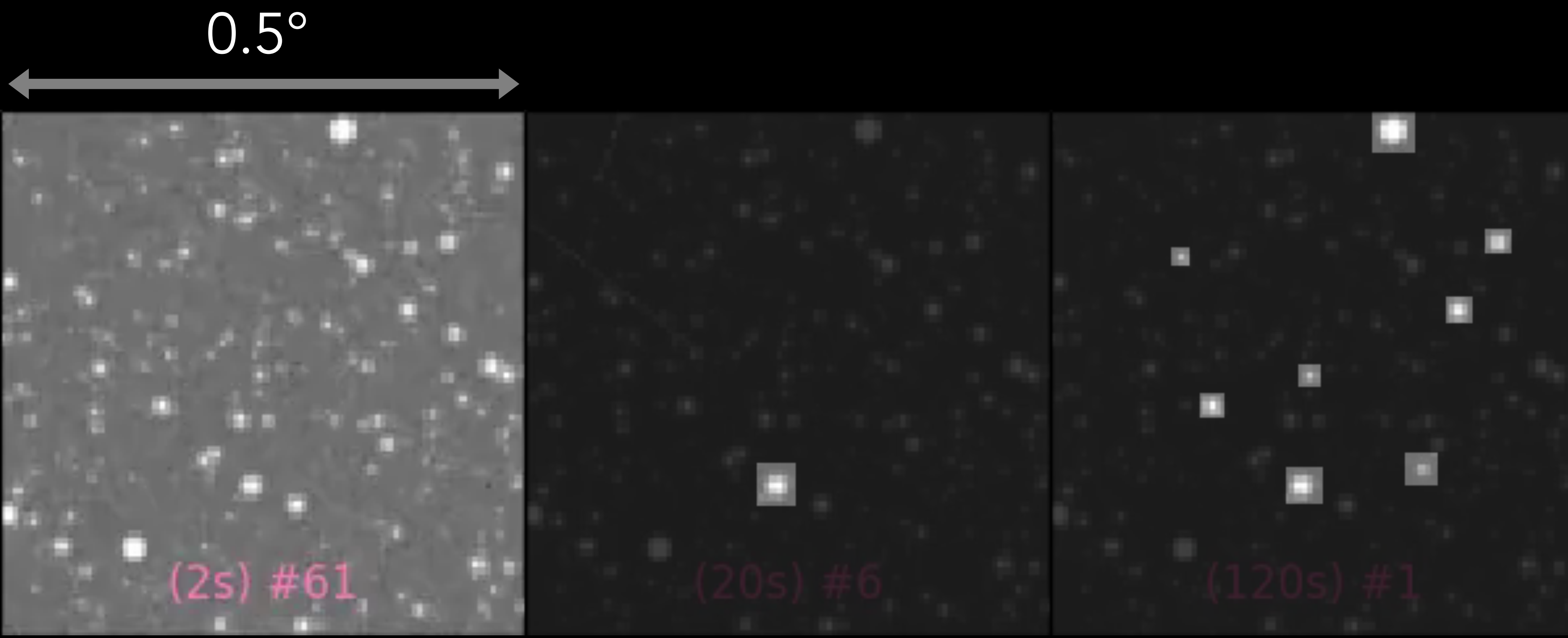


The TESS CCDs take **2 second** exposures. These data are used for guiding, but not downloaded.

Postage stamps will be downloaded at **20 second** cadence for 1,000 bright **asteroseismology** targets.

TESS Slides from Zach Berta-Thompson

(60X speed)

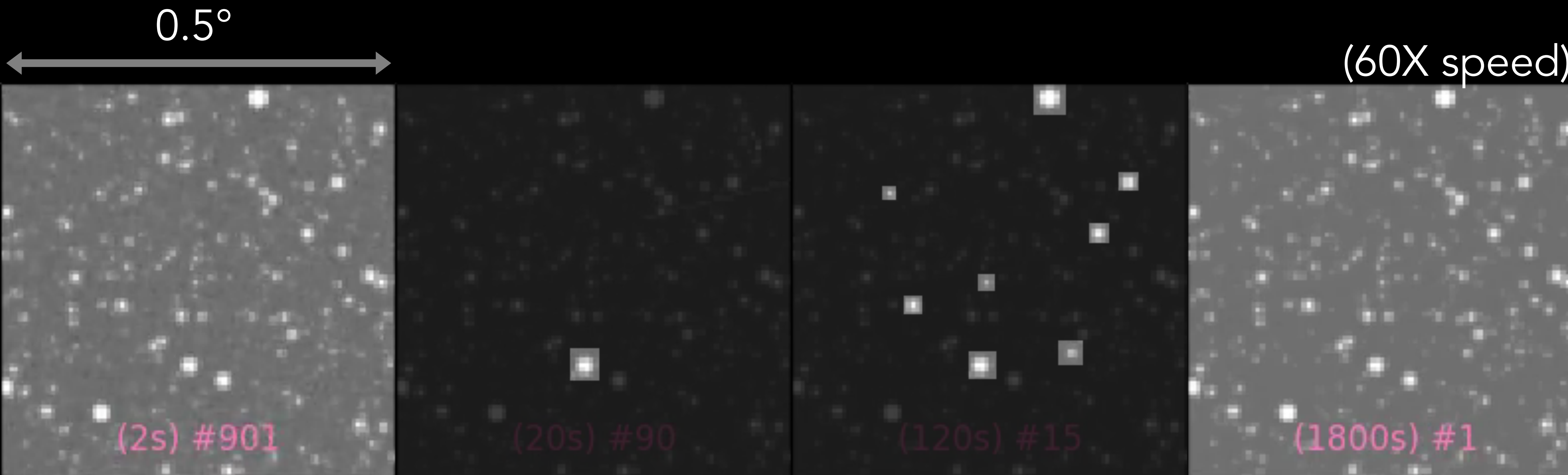


The TESS CCDs take **2 second** exposures. These data are used for guiding, but not downloaded.

Postage stamps will be downloaded at **20 second** cadence for 1,000 bright **asteroseismology** targets.

Postage stamps will be downloaded at **2 minute** cadence for 200,000 stars, primarily good **planet-search** hosts.

TESS Slides from Zach Berta-Thompson



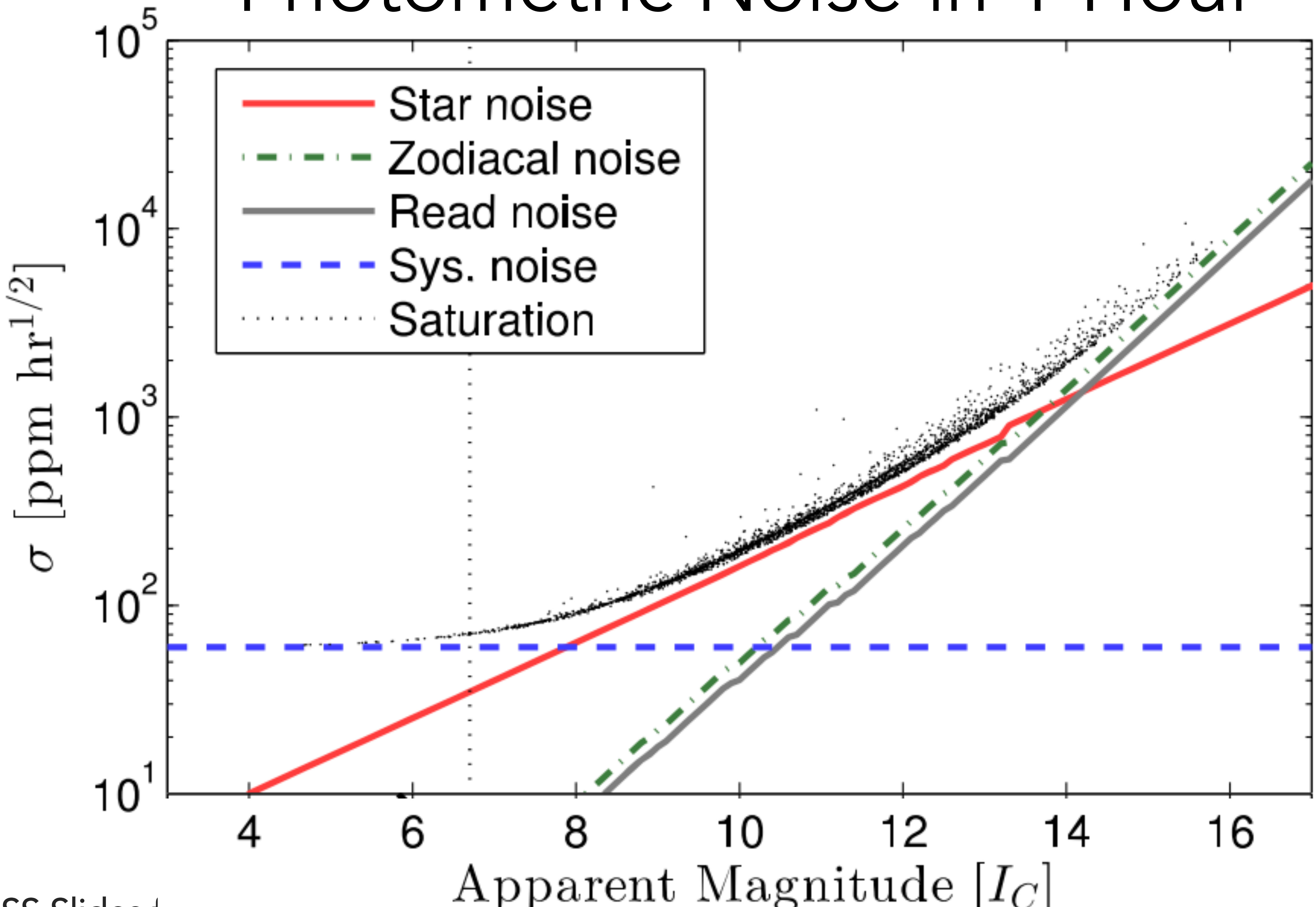
The TESS CCDs take **2 second** exposures. These data are used for guiding, but not downloaded.

Postage stamps will be downloaded at **20 second** cadence for 1,000 bright **asteroseismology** targets.

Postage stamps will be downloaded at **2 minute** cadence for 200,000 stars, primarily good **planet-search** hosts.

Full frame images will be downloaded at **30 minute** cadence.

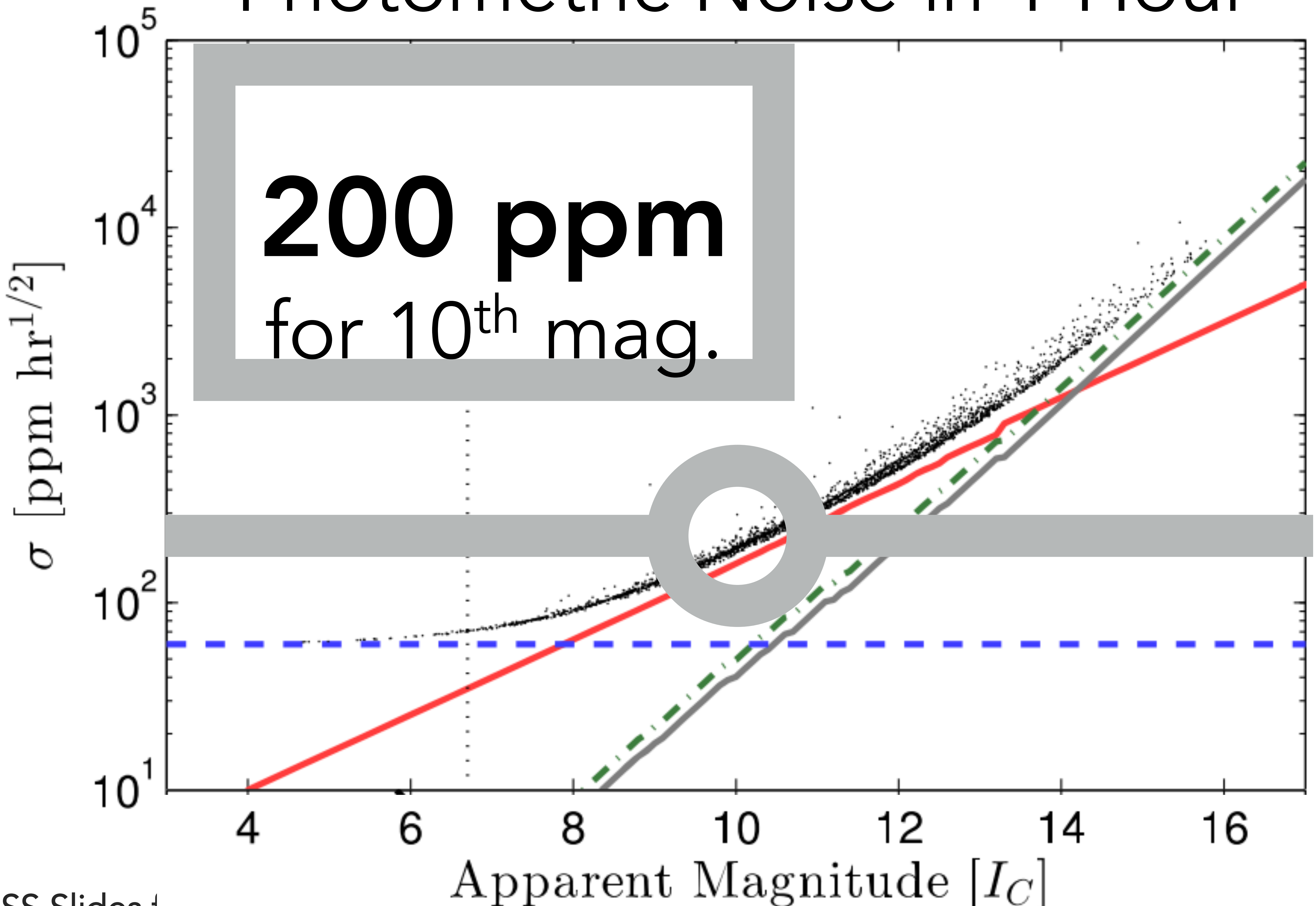
Photometric Noise in 1 Hour



TESS Slides f
Zach Berta-Thompson

Ricker et al. (2014); Sullivan et al. (2015)

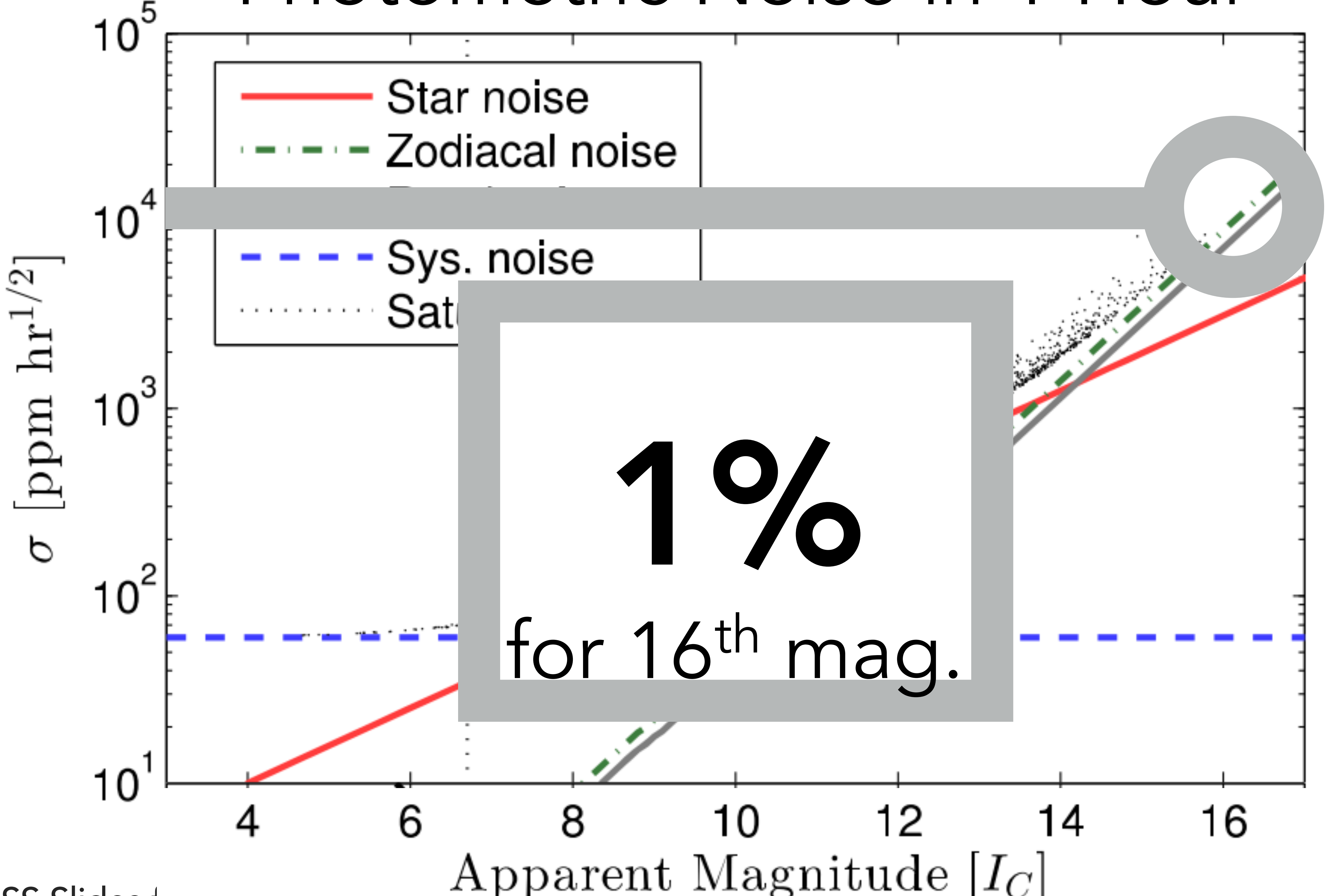
Photometric Noise in 1 Hour



TESS Slides f
Zach Berta-Thompson

Ricker et al. (2014); Sullivan et al. (2015)

Photometric Noise in 1 Hour



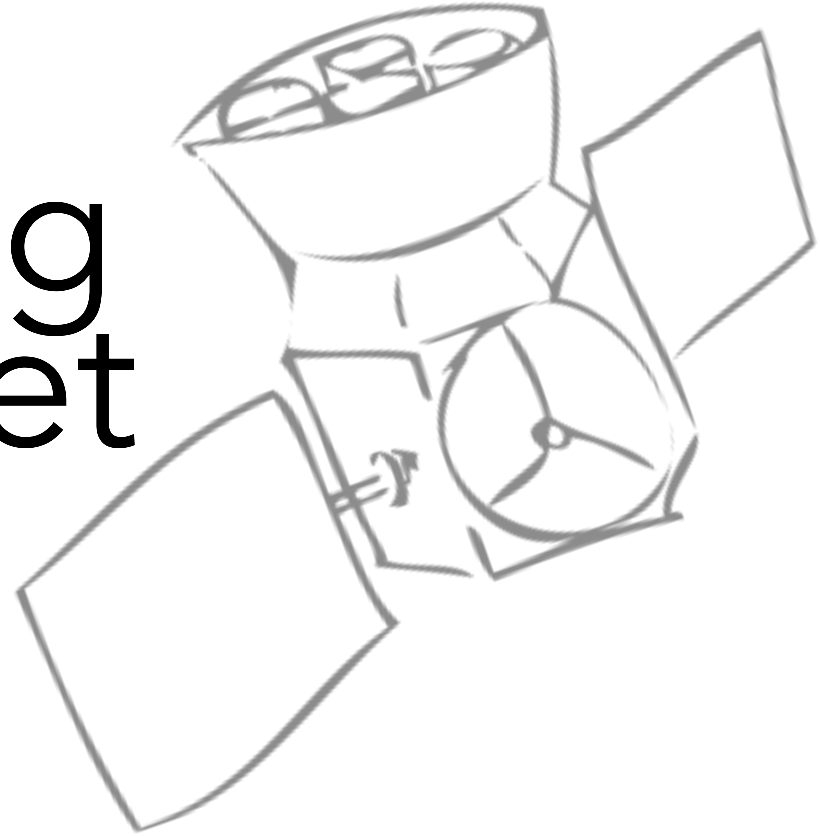
TESS Slides f

Zach Berta-Thompson

Ricker et al. (2014); Sullivan et al. (2015)

TESS Slides from
Zach Berta-Thompson

Transiting
Exoplanet
Survey
Satellite

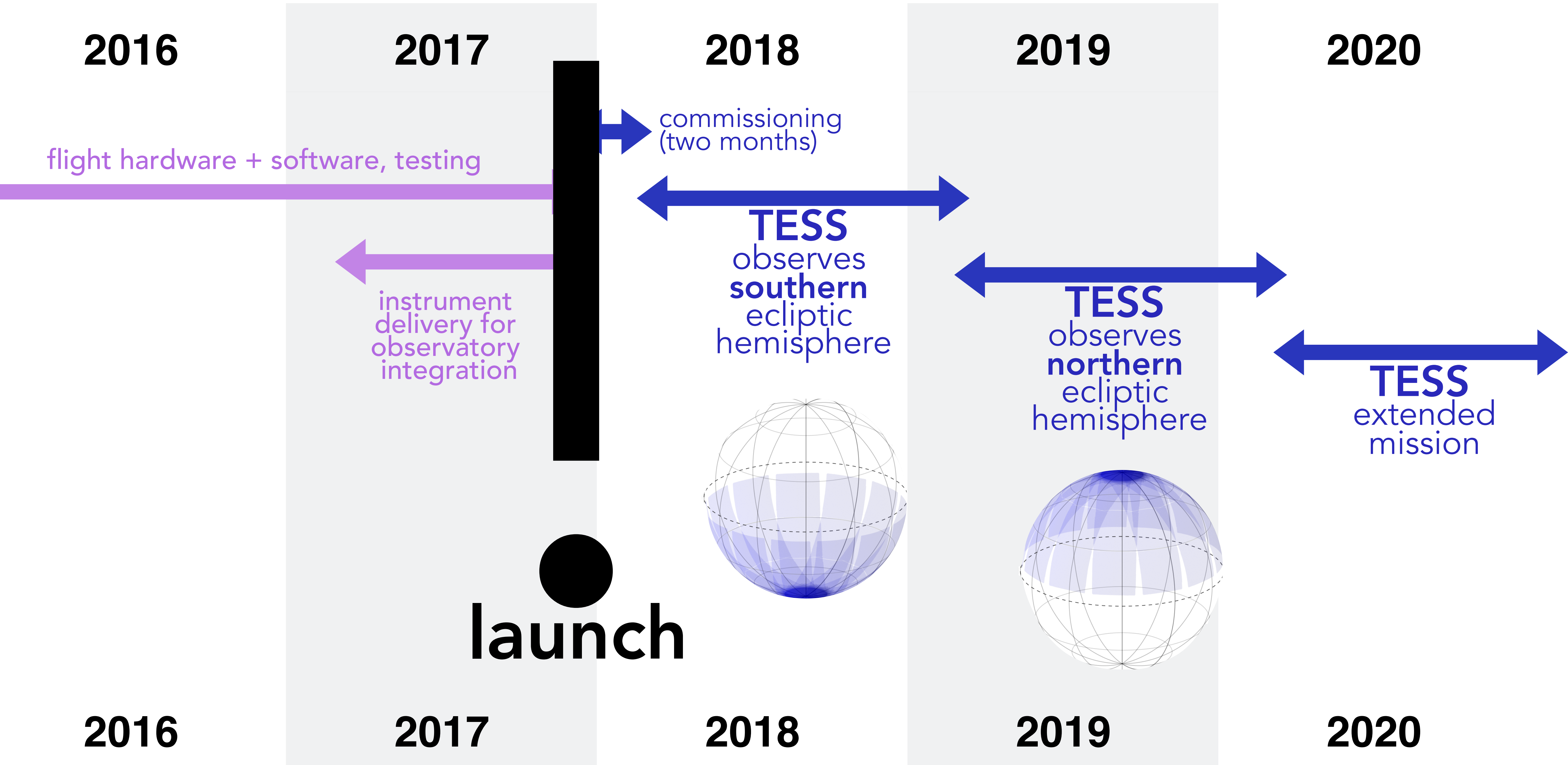


Why do we need it?
How will it work?
What data will it collect?
When does it happen?

TESS is scheduled to launch
20 December 2017
on a SpaceX Falcon 9.

TESS Slides from Zach Berta-Thompson

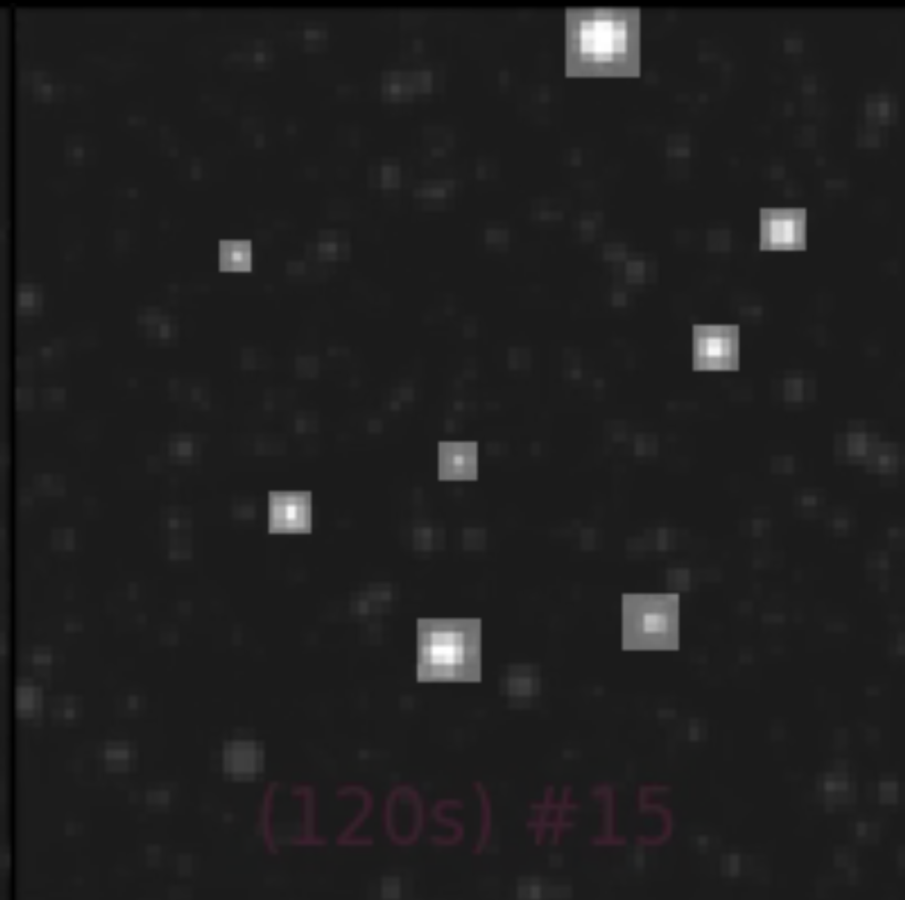
TESS timeline:



TESS Slides from Zach Berta-Thompson

TESS data release policy:

20 second stamps will be analyzed by the TESS Asteroseismic Science Consortium.



2 minute stamps will be processed by NASA Ames. Data, light curves, and TESS Objects of Interest will be released to MAST within 4 months of downlink.

30 minute full-frame images will be released as calibrated pixel data to MAST, within 4 months of downlink.

TESS Guest Investigator Program

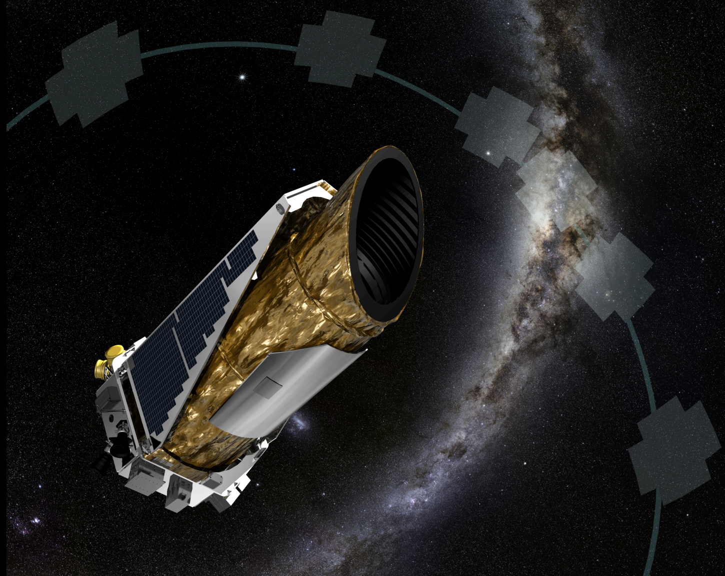
The astronomical community can apply for:

- new targets to be observed at 2-minute cadence (10,000/yr)
- new analyses of TESS full-frame images.

Investigators at US institutions can apply for funding ($2.5M/yr).

Cycle 1 call for proposals will be released ***December 2016.***

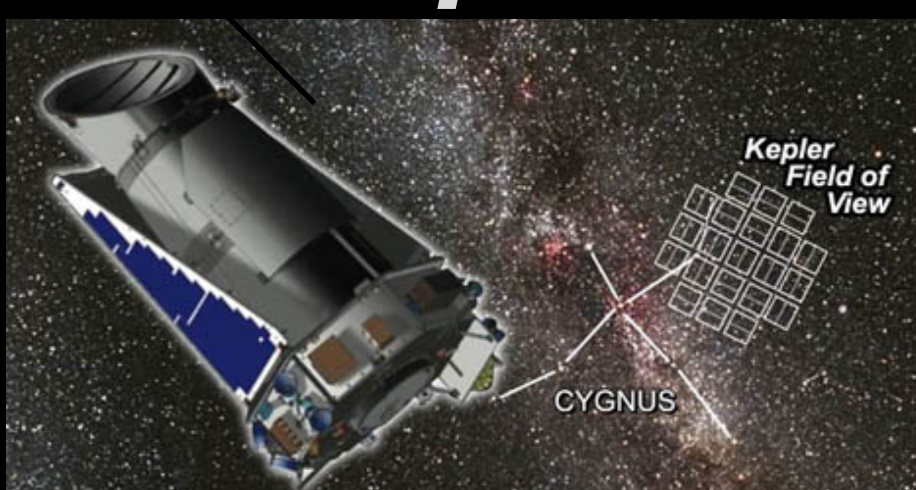
Guest Investigator Program office will be source for software and documentation for community. See tess.gsfc.nasa.gov!



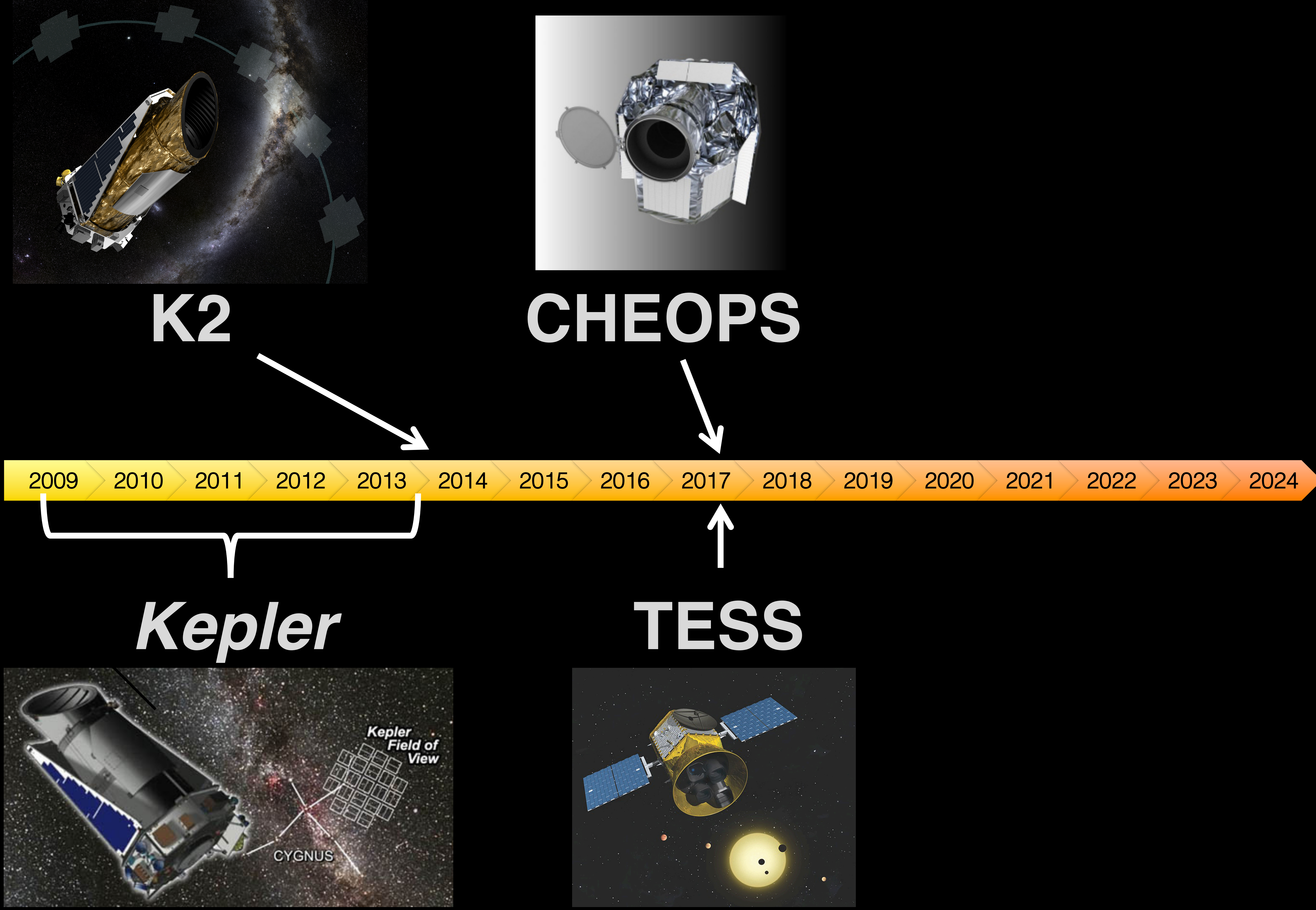
K2

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Kepler



TESS



K2
CHEOPS
2009
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2024
Kepler
TESS
Kepler Field of View
CYGNUS

CHEOPS

CHEOPS

CHaracterising

ExOPlanet

Satellite

CHEOPS

Cosmic Vision Themes	What are the conditions for planet formation and the emergence of life?
Primary Goal	Characterize transiting exoplanets orbiting bright host stars
Targets	Known exoplanet host stars V mag ≤ 12
Wavelength	0.4 – 1.1 microns
Orbit	Sun-synchronous, 650-800 km
Lifetime	3.5 years (goal = 5 years)

http://sci.esa.int/cheops/

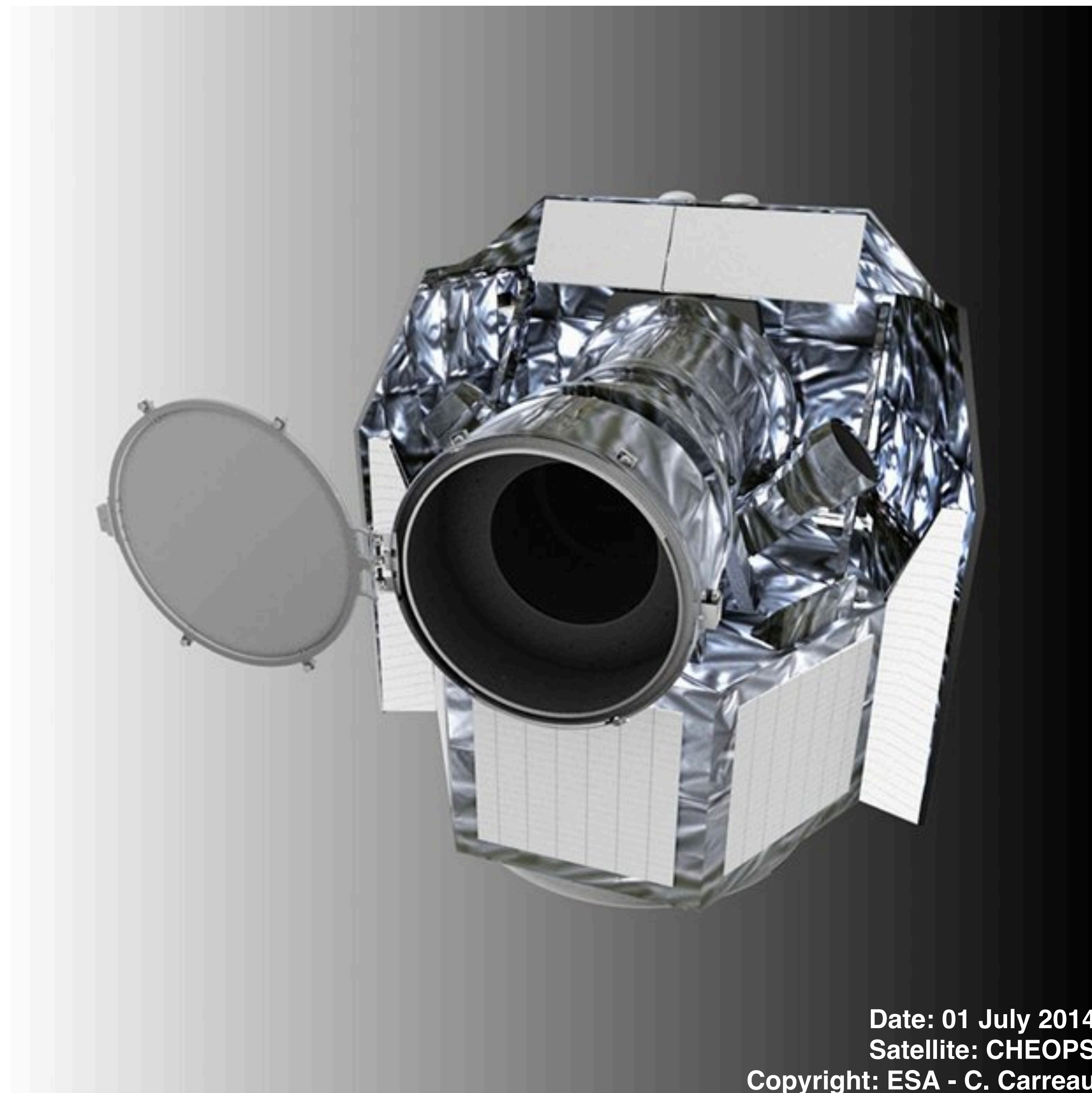
CHEOPS

Spacecraft dimensions:
1.5m x 1.4m x 1.5m

Telescope Aperture:
33cm

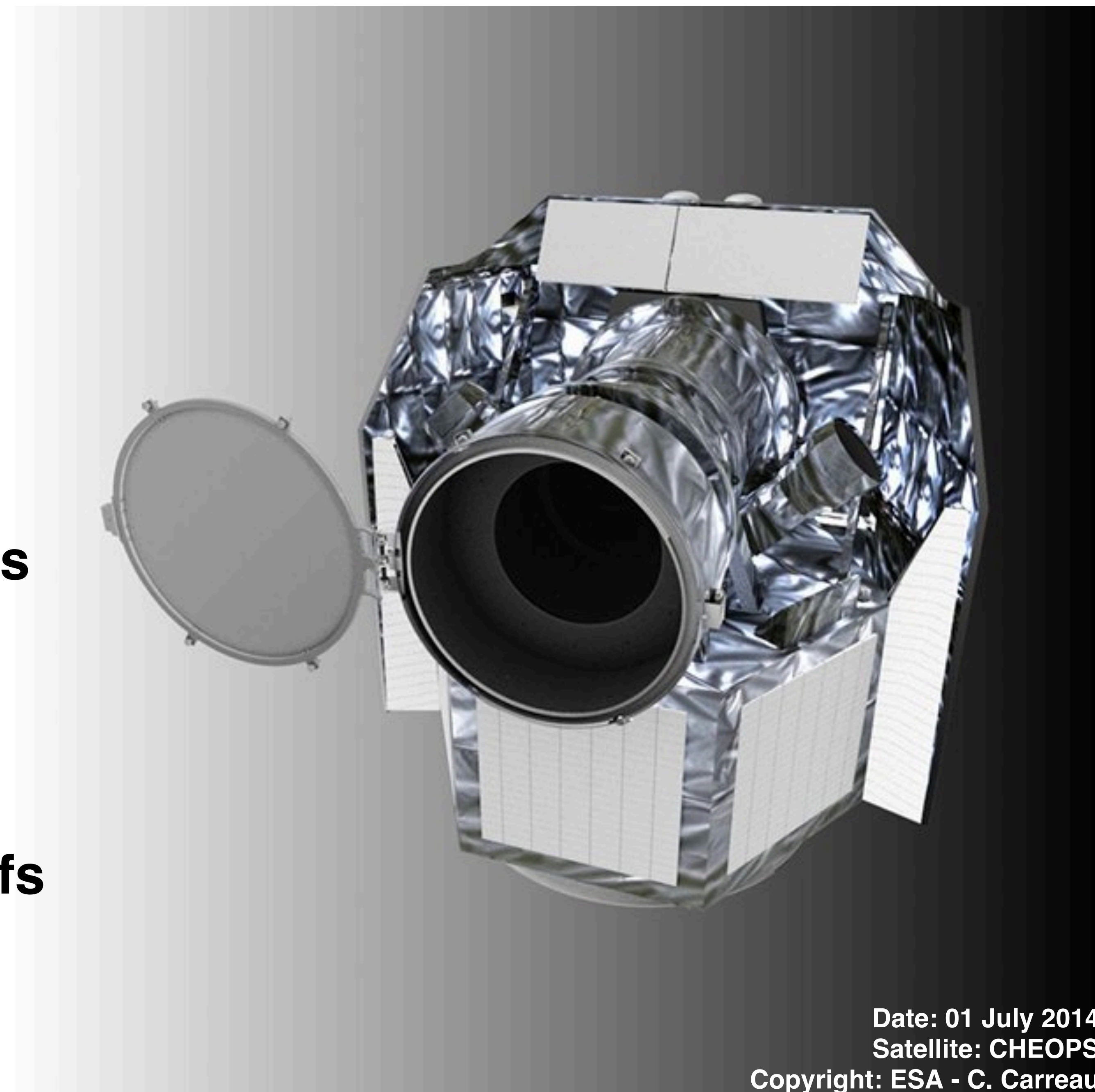
Community Science:
20% of mission

Launch Plan:
Shared launch in 2017



CHEOPS

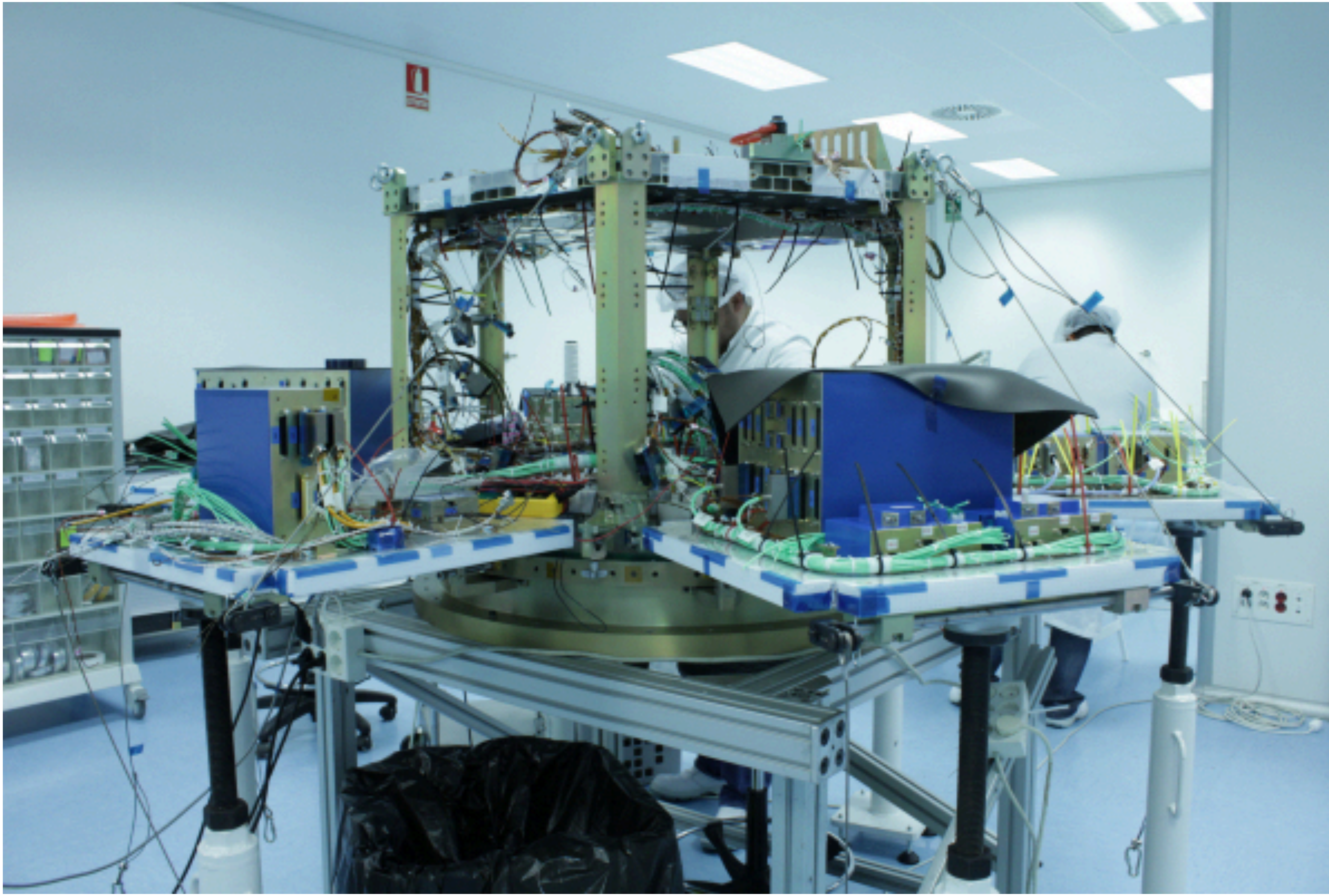
Precision Goal: 10% planet radii



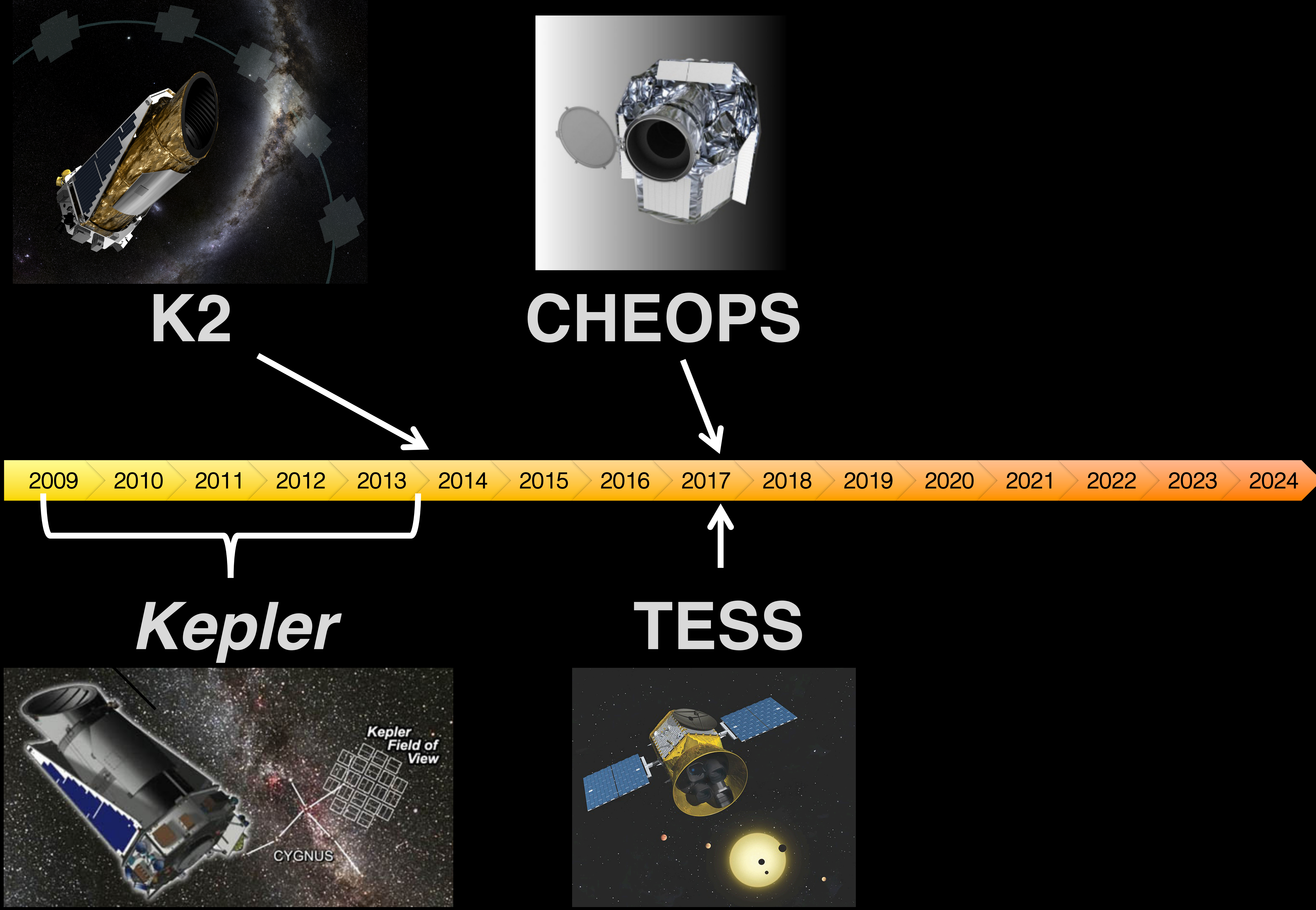
Earth-sized planets transiting G5 dwarfs
Precision: 20 ppm in 6 hrs
V mag = 6 – 9

Neptune-sized planets transiting K dwarfs
Precision: 85 ppm in 3 hrs
V mag = 9 – 12
SNR = 30

The CHEOPS Engineering Model is under construction!



CHEOPS flight platform during harness integration. Credit: ADS - Spain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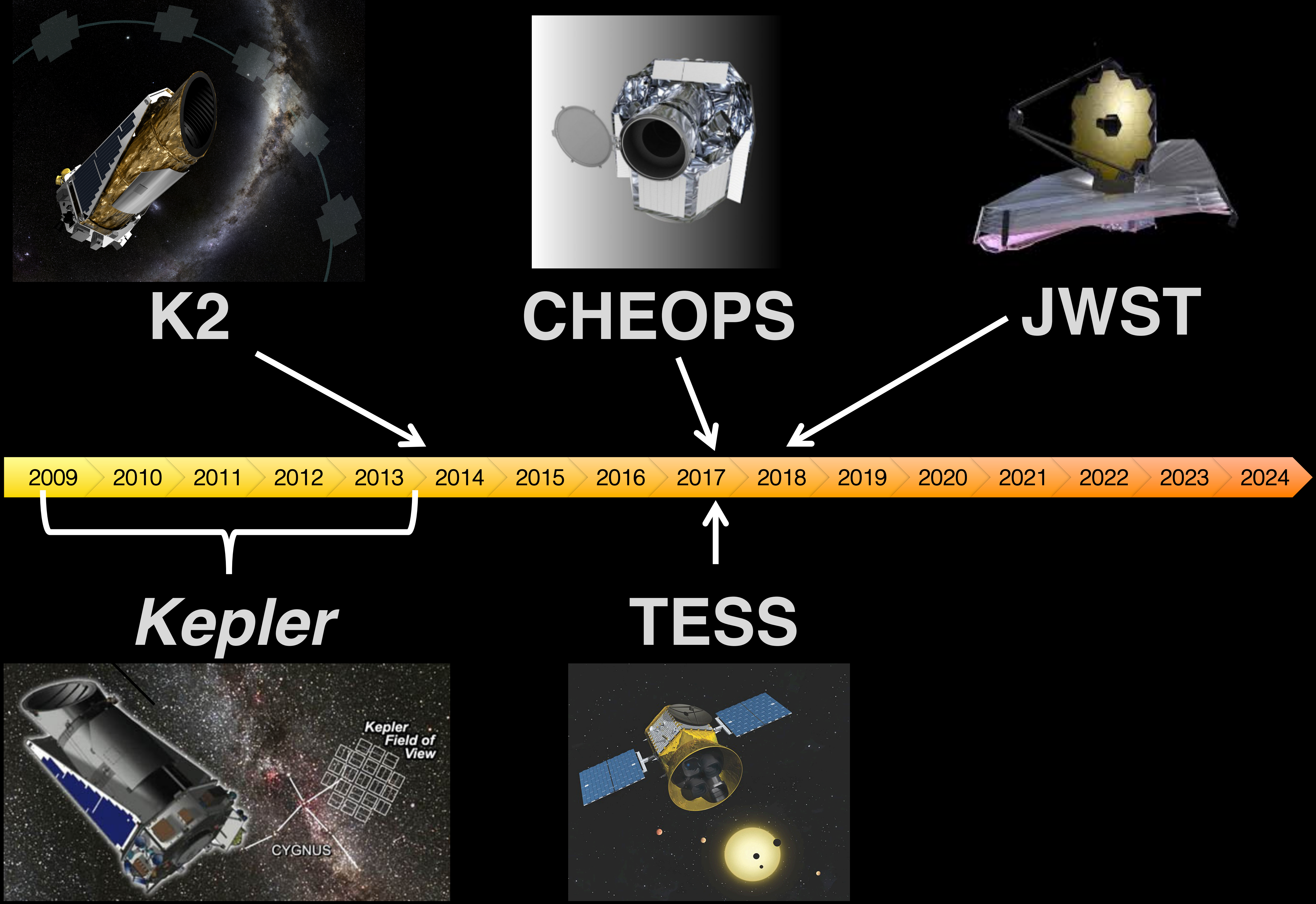
Kepler Field of View
CYGNUS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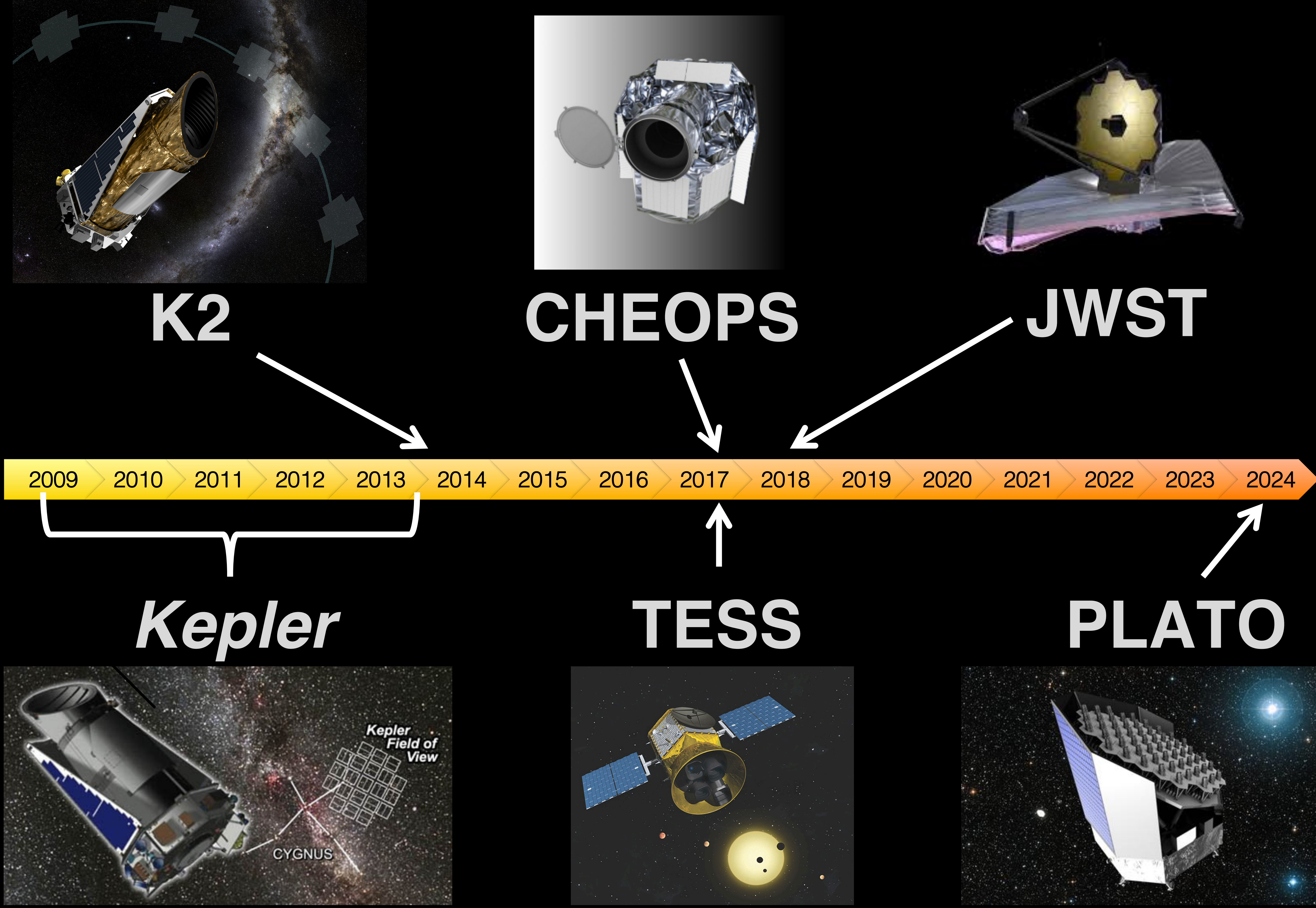
Kepler Field of View
CYGNUS


K2
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2022
2023
2024
Kepler
TESS
PLATO
Kepler Field of View
CYGNUS

PLAnetary

Transits

and

Oscillations

of

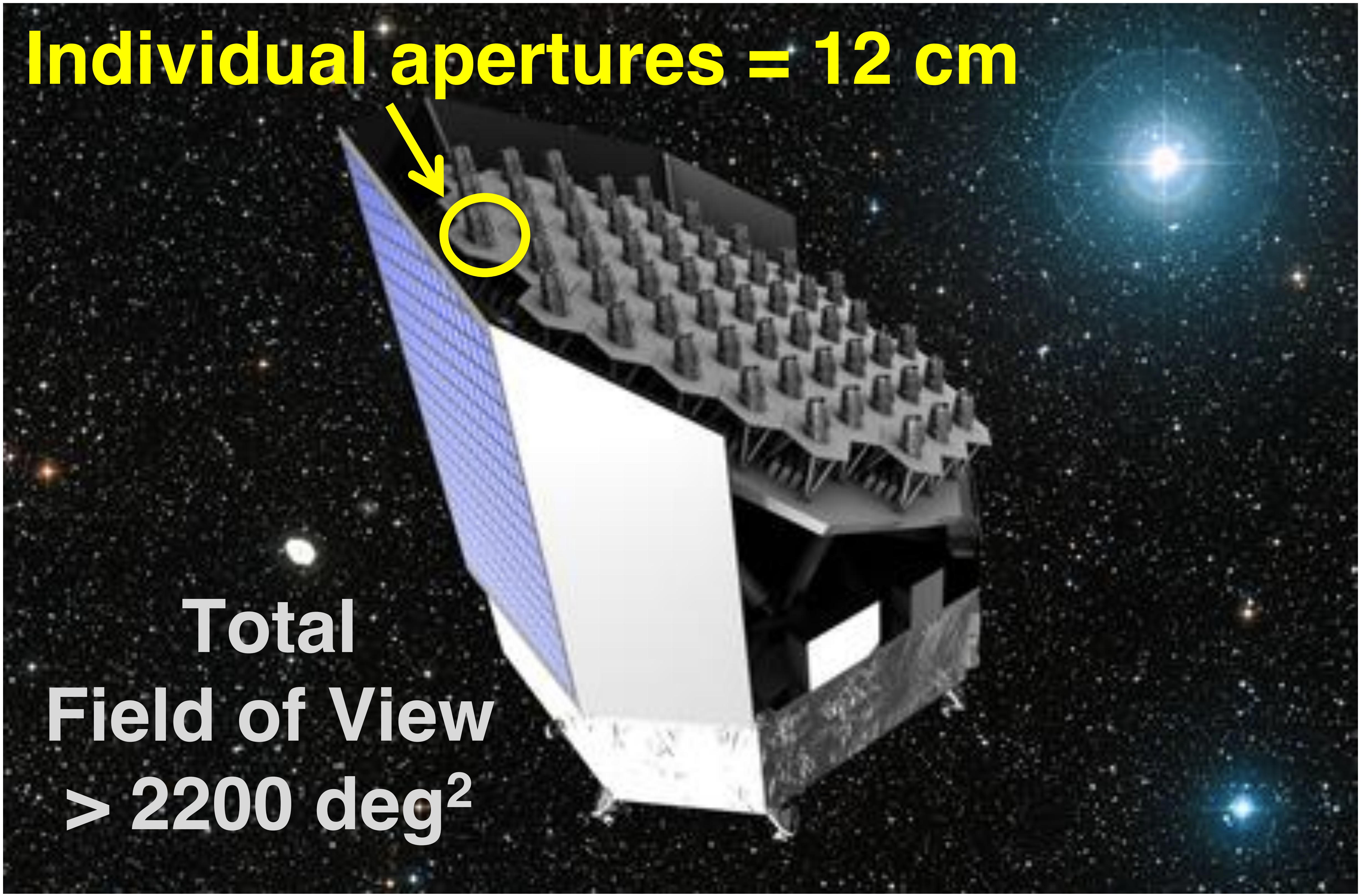
stars

PLATO

Launch: by 2024
Lifetime: 6 years
Location: L2

PLATO

One Possible Design for PLATO



Credit: Thales Alenia Space, European Space Agency, Digitized Sky Survey 2 (STScI)

PLATO

How long will PLATO observe?

Step & Stares: month(s)

Long Pointings: 2-3 years

Rauer et al. 2014, Experimental Astronomy, 38, 249

PLATO

How long will PLATO observe?

Step & Stares: month(s)

Long Pointings: 2-3 years

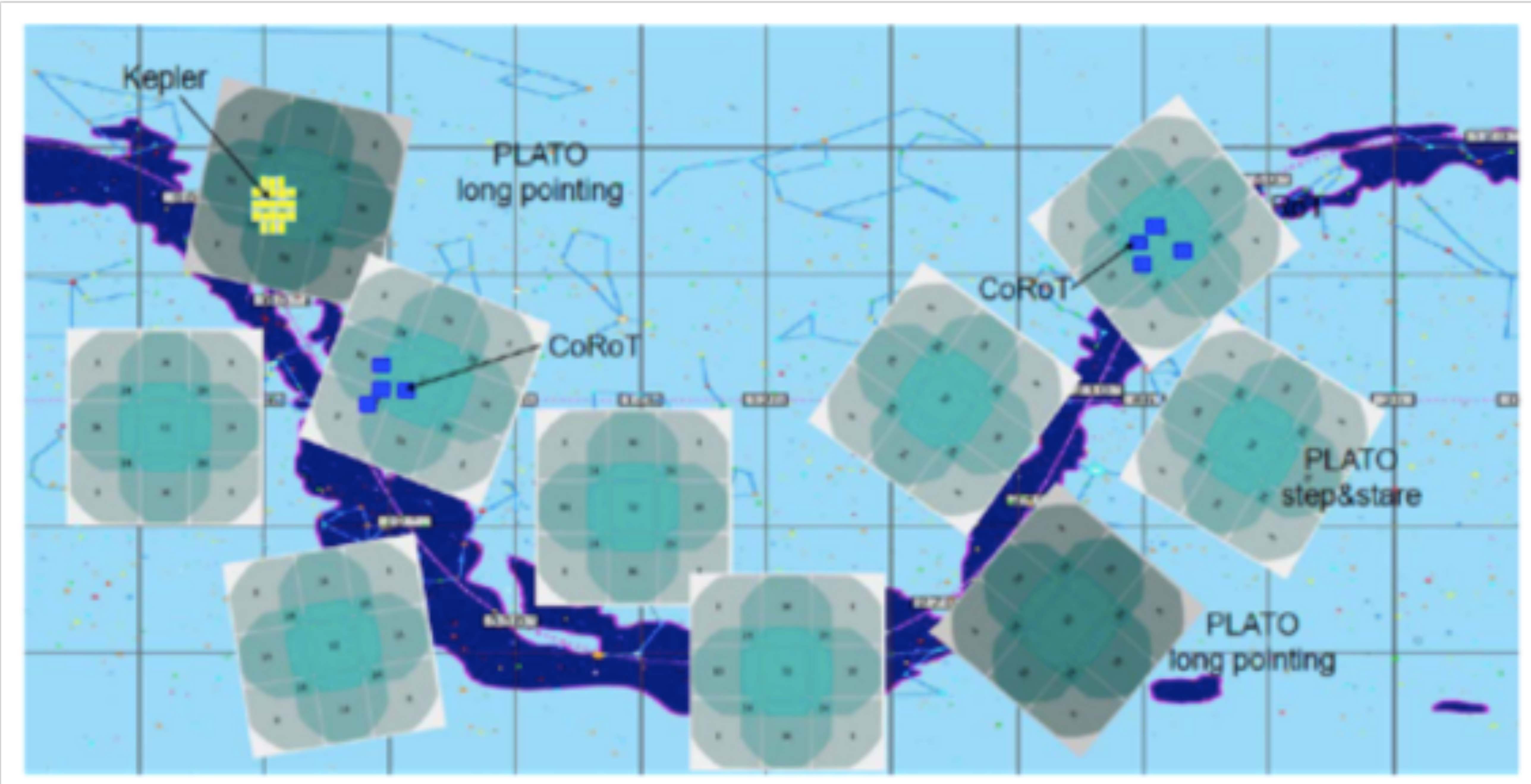
How many stars will PLATO observe?

Each Field: 150,000

Full Mission: 1,000,000

Rauer et al. 2014, Experimental Astronomy, 38, 249

PLATO will Observe a Million Stars



The exact pointings have not been set.

How will PLATO observe?

PLATO

Rauer et al. 2014, Experimental Astronomy, 38, 249

How will PLATO observe?

PLATO

“Normal” Cameras:

Bandpass: 500 -1000 nm

Magnitude Range: 8 – 16

Cadence: 25 s

Rauer et al. 2014, Experimental Astronomy, 38, 249

How will PLATO observe?

“Normal” Cameras:

Bandpass: 500 -1000 nm
Magnitude Range: 8 – 16
Cadence: 25 s

“Fast” Cameras:

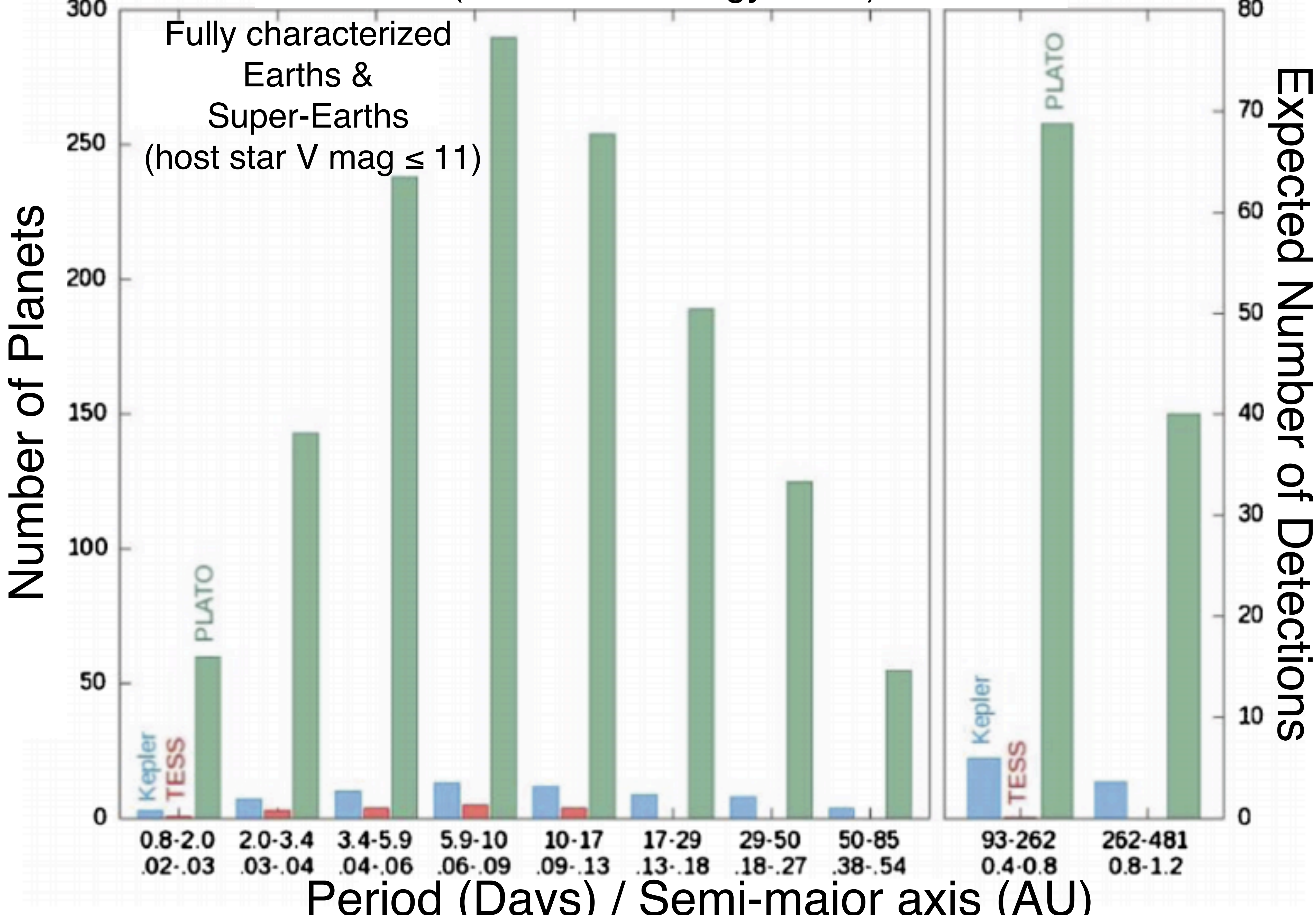
Bandpass: Broadband filter
Magnitude Range: 4 – 8
Cadence: 2.5 s

PLATO

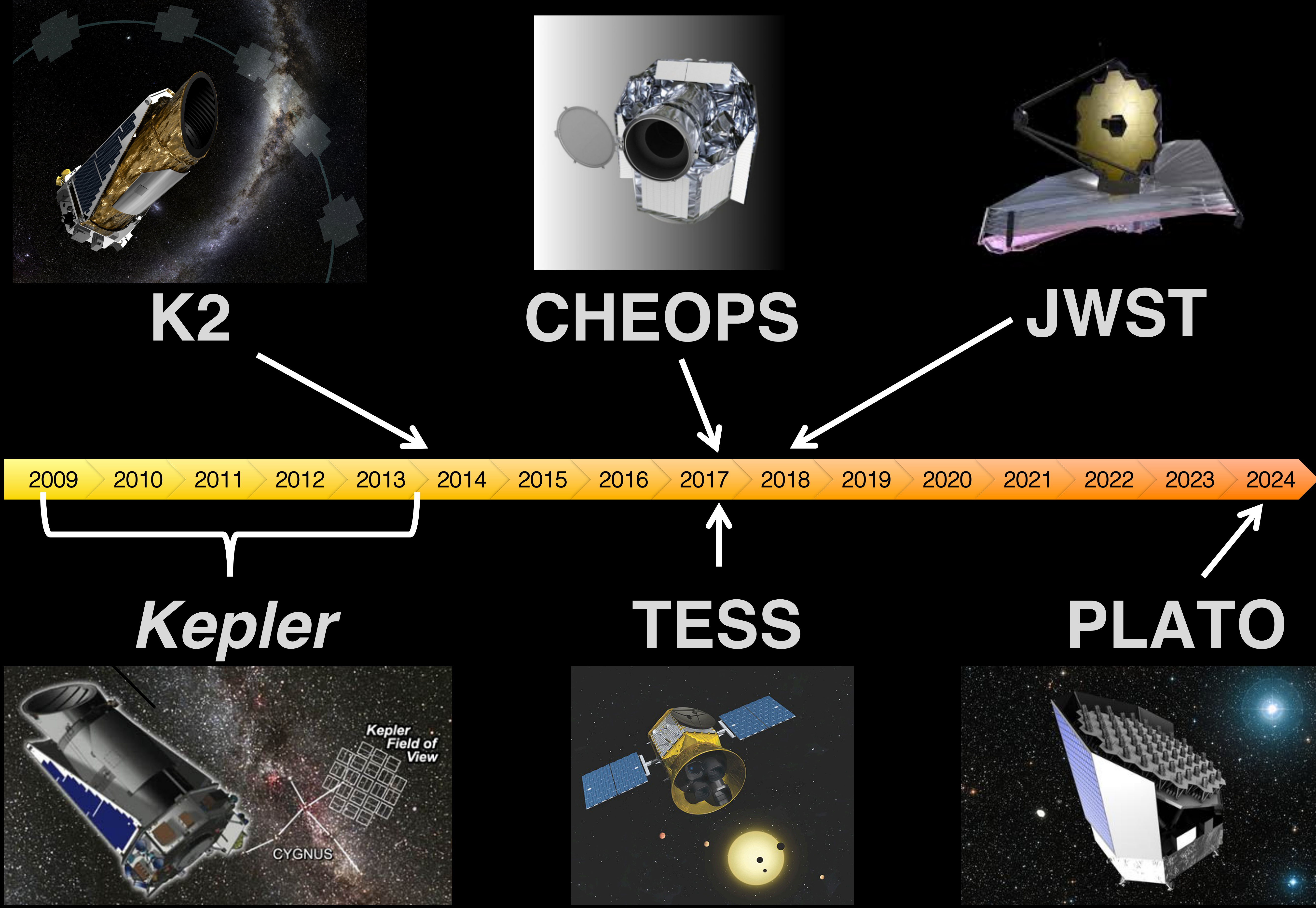
Rauer et al. 2014, Experimental Astronomy, 38, 249

Projected Yield of Fully Characterized Small Planets

(Asteroseismology & RV)



Rauer et al. 2014, Experimental Astronomy, 38, 249


K2
CHEOPS
JWST
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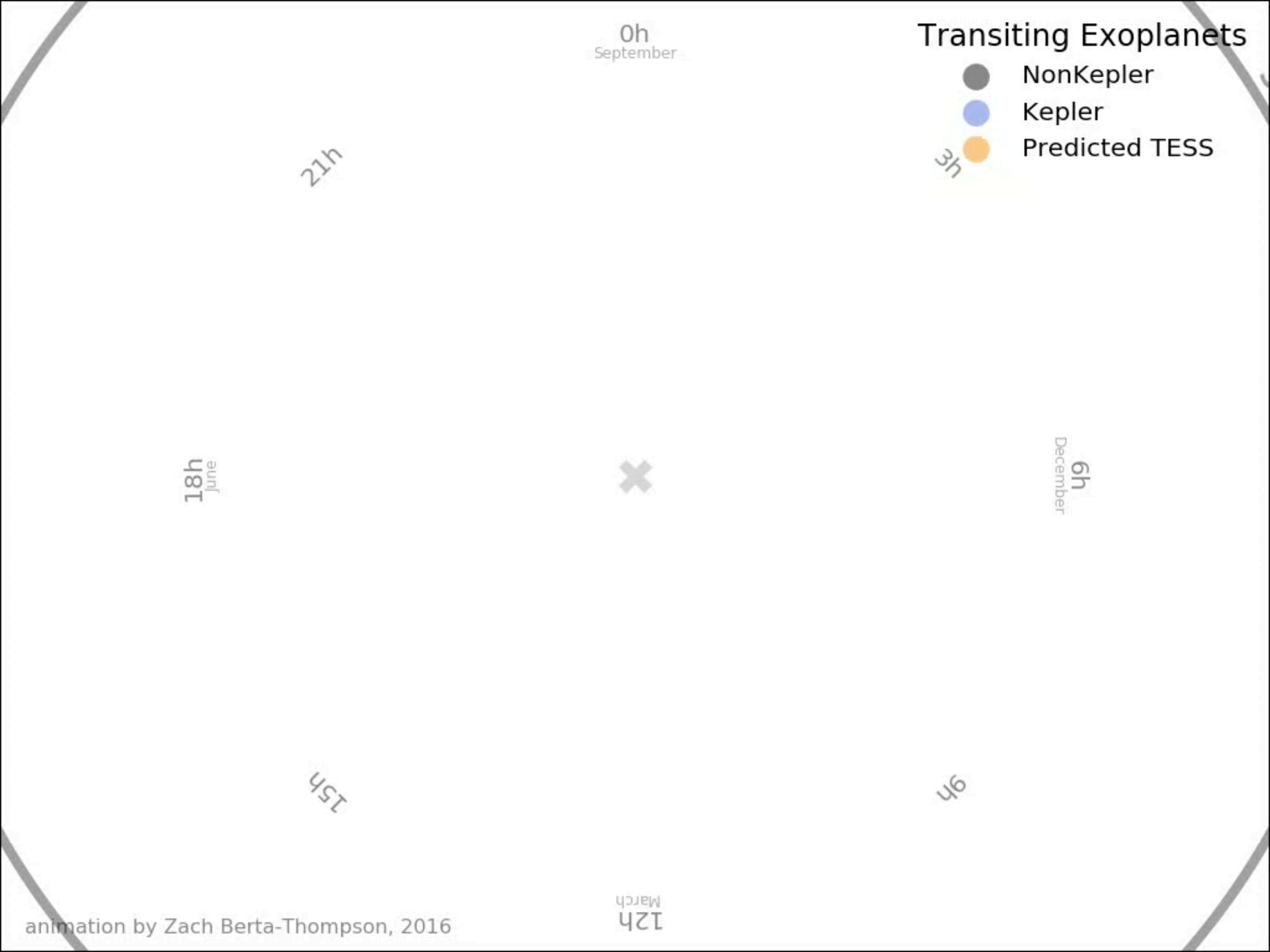
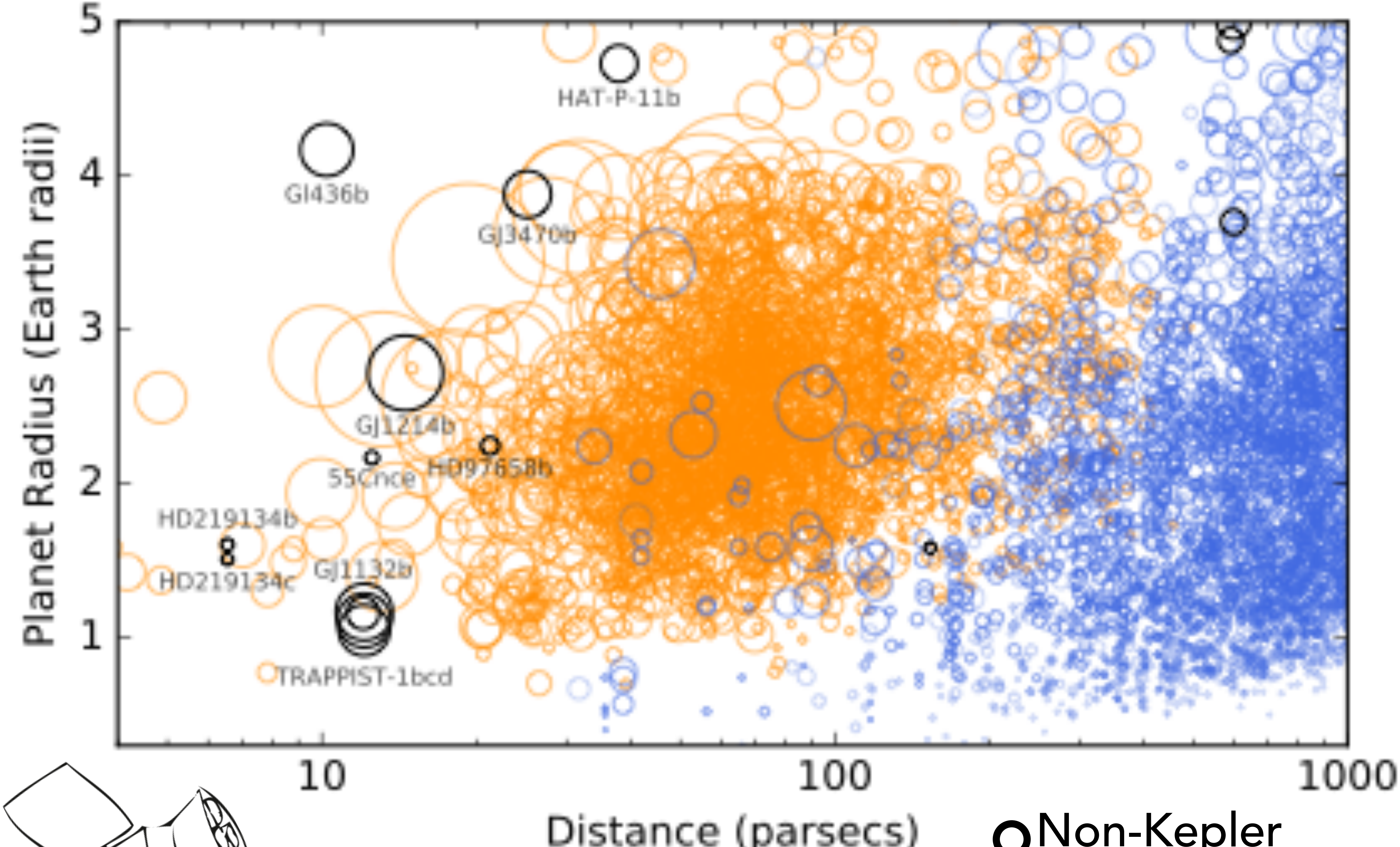
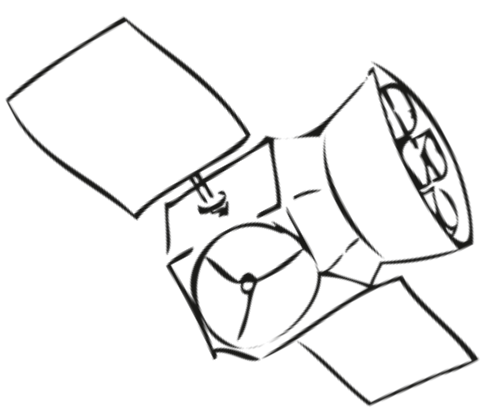
2024
Kepler
TESS
PLATO
Kepler Field of View
CYGNUS


Transiting Exoplanets
NonKepler
Kepler
Predicted TESS
0h
September
3h
6h
December
9h
12h
March
15h
18h
June
21h
animation by Zach Berta-Thompson, 2016

TESS Slides from Zach Berta-Thompson

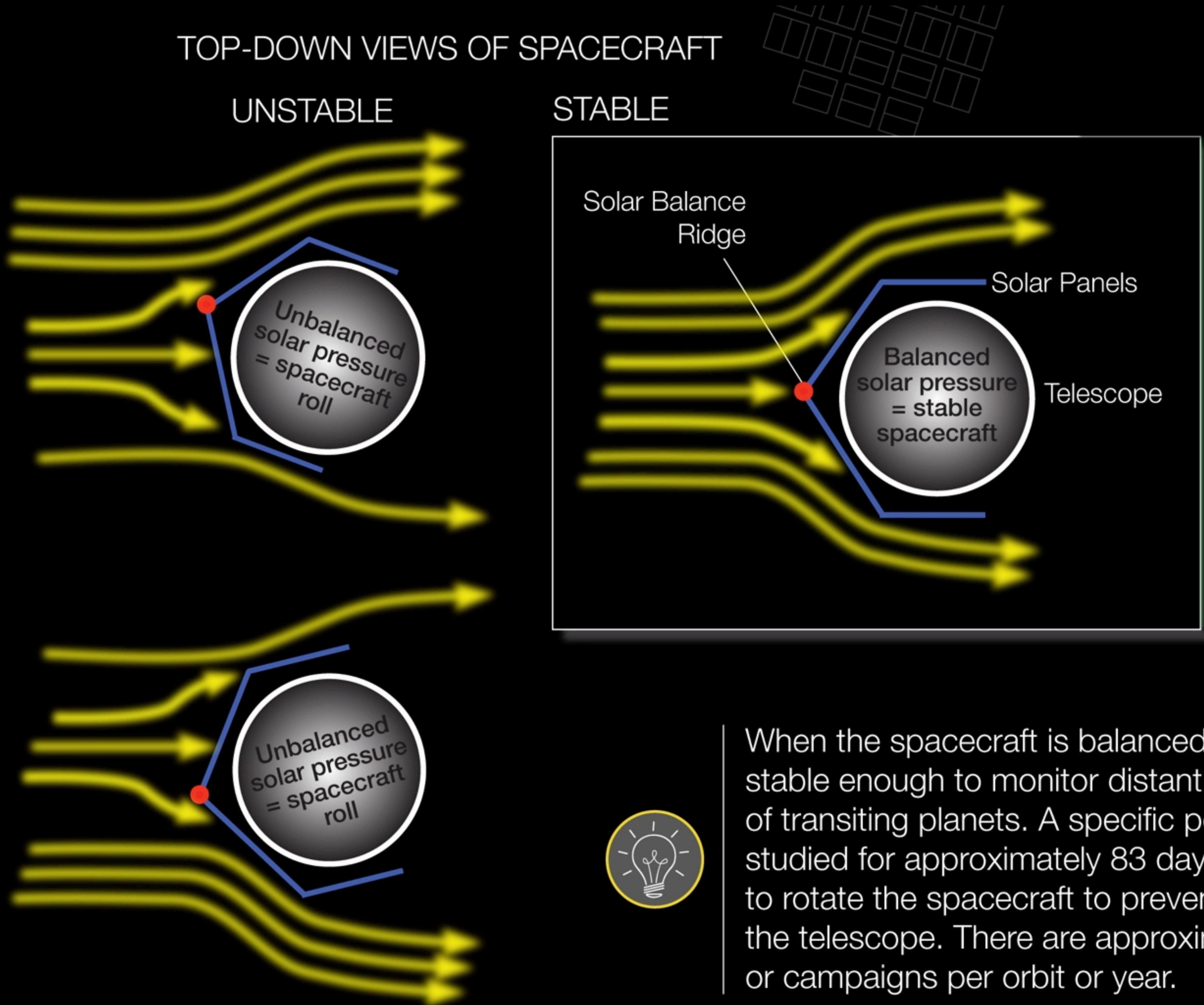




Non-Kepler
Kepler/K2
TESS (expected)

Additional Slides

The K2 Mission is a Balancing Act



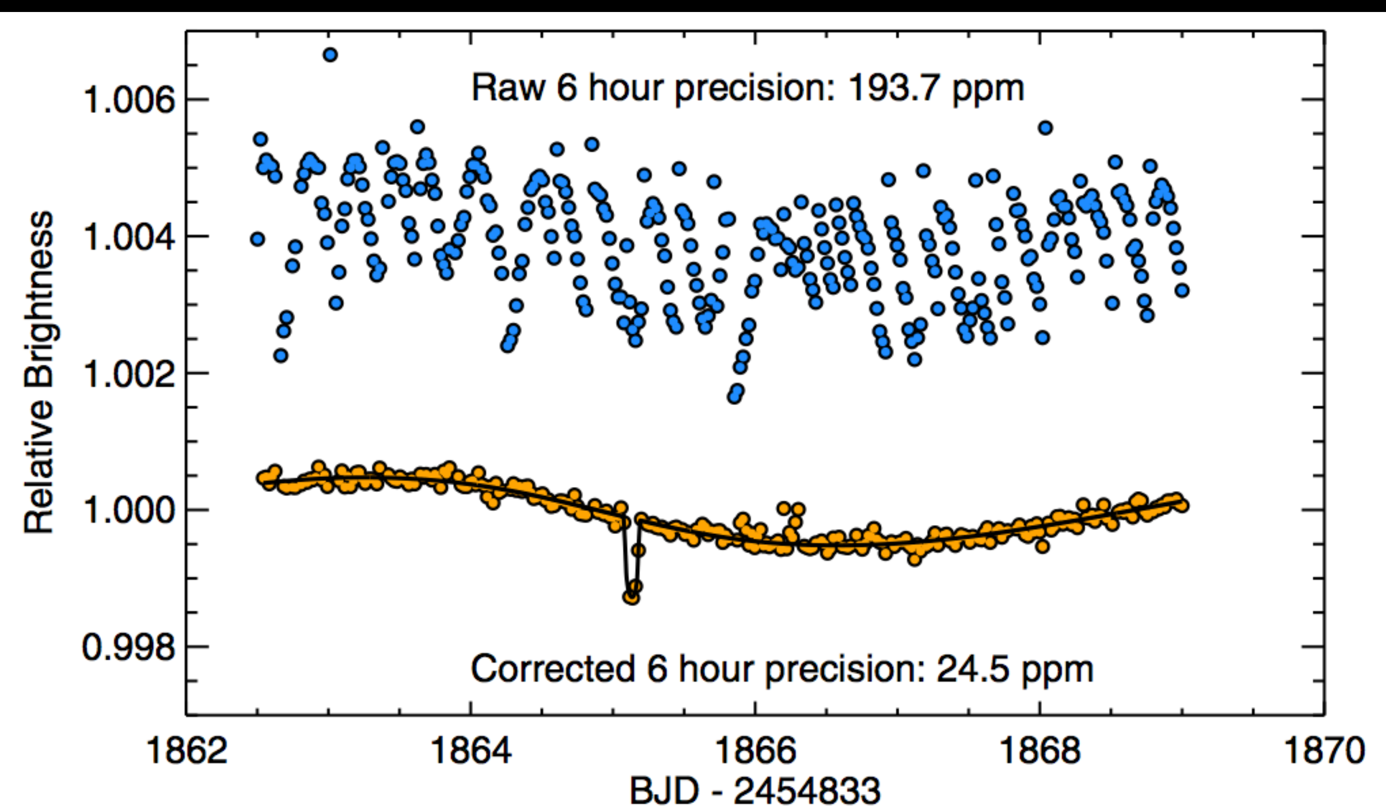
When the spacecraft is balanced, the telescope is stable enough to monitor distant stars in search of transiting planets. A specific portion of the sky is studied for approximately 83 days, until it is necessary to rotate the spacecraft to prevent sunlight from entering the telescope. There are approximately 4.5 viewing periods or campaigns per orbit or year.

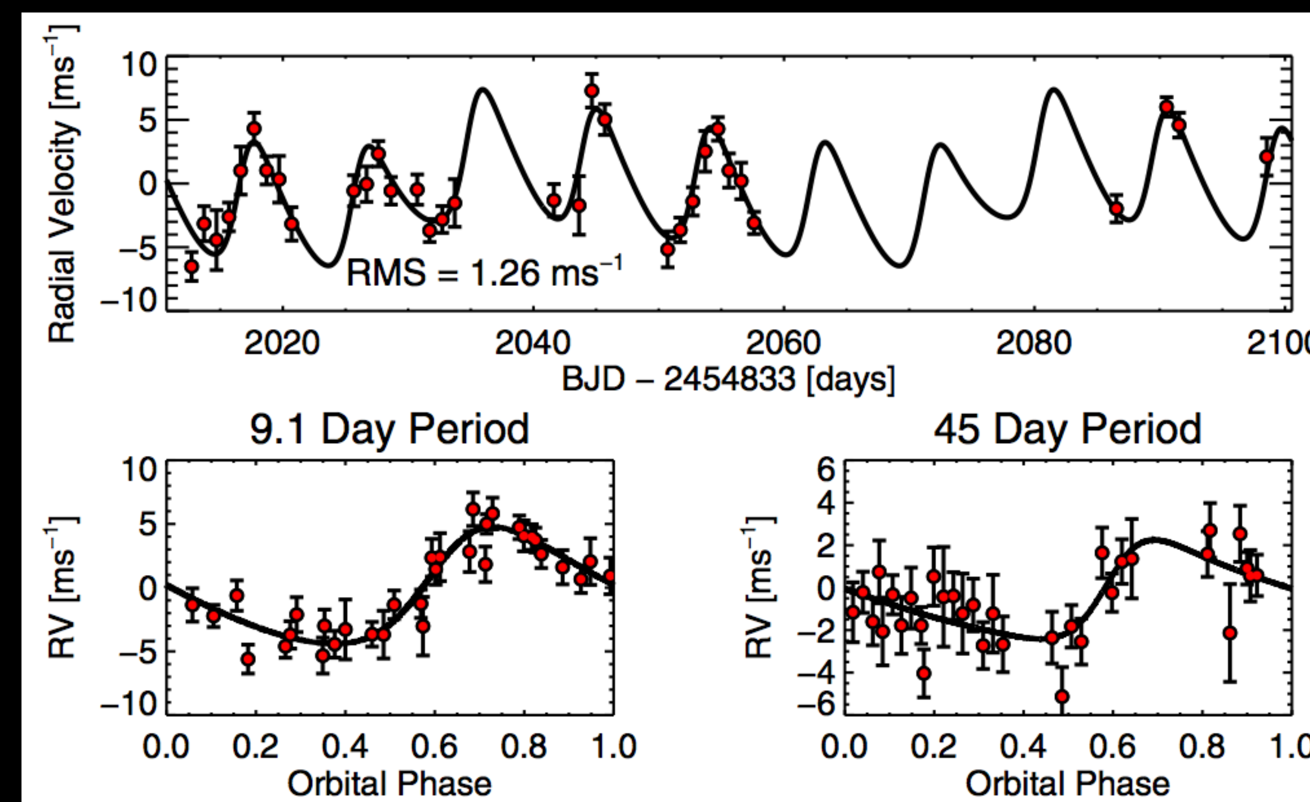
http://www.nasa.gov/kepler/keplers-second-light-how-k2-will-work

Some Bright Stars Host Small Planets

CHARACTERIZING K2 PLANET DISCOVERIES: A SUPER-EARTH TRANSITING THE BRIGHT K DWARF HIP 116454

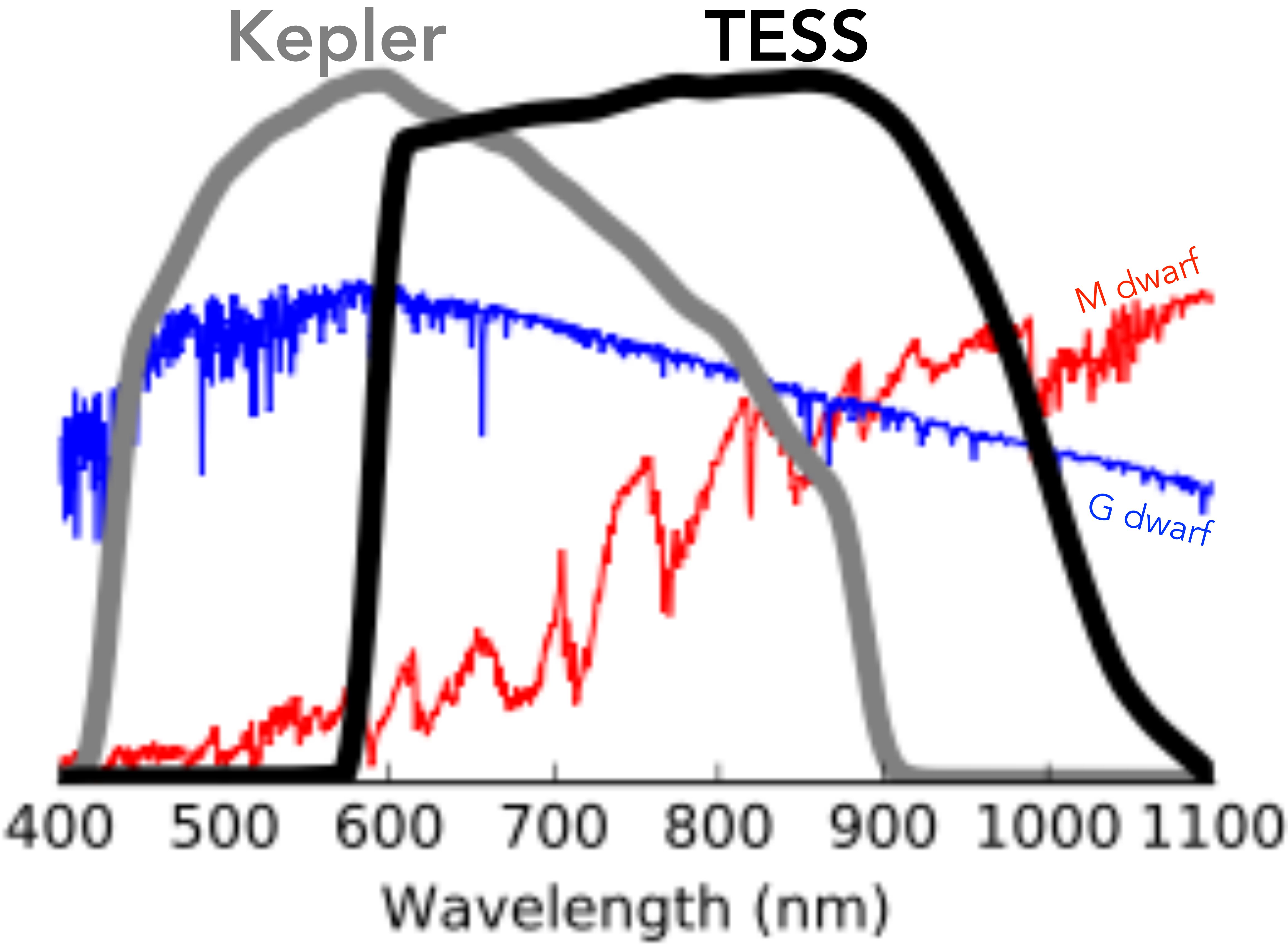
ANDREW VANDERBURG[1,28], BENJAMIN T. MONTET[1,2,28], JOHN ASHER JOHNSON[1,29], LARS A. BUCHHAVE[1], LI ZENG[1],





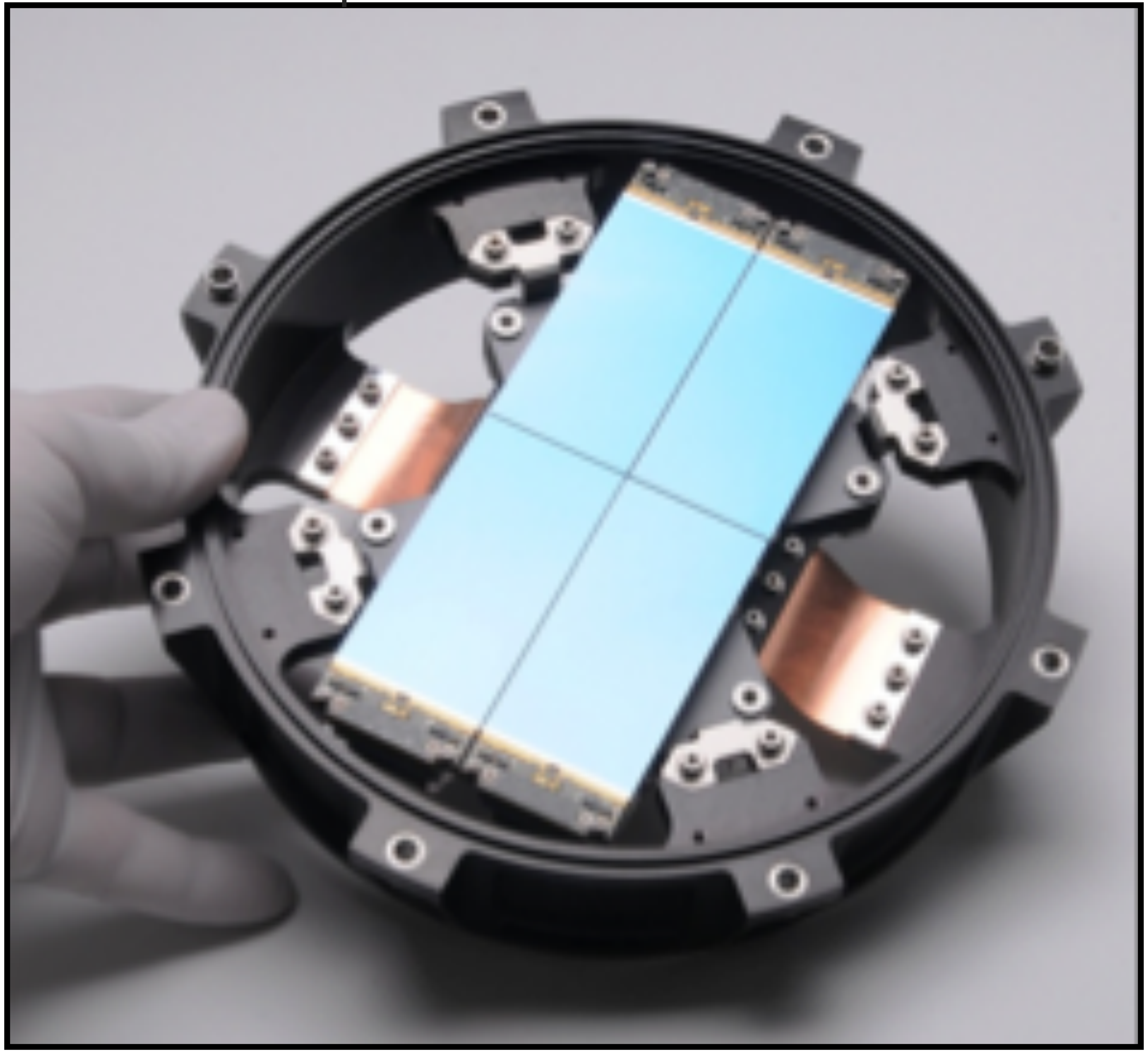
Vanderburg+ 2015, ApJ, 800, 59

TESS Slides from Zach Berta-Thompson



Ricker et al. (2014), Sullivan et al. (2015)

TESS Slides from Zach Berta-Thompson



deep depletion,
frame-transfer CCDs

Ricker et al. (2014), Sullivan et al. (2015)

TESS Follow-up Observations

The TESS Science Office will identify transit candidates (TOIs), and use Kepler techniques to remove easy false positives.

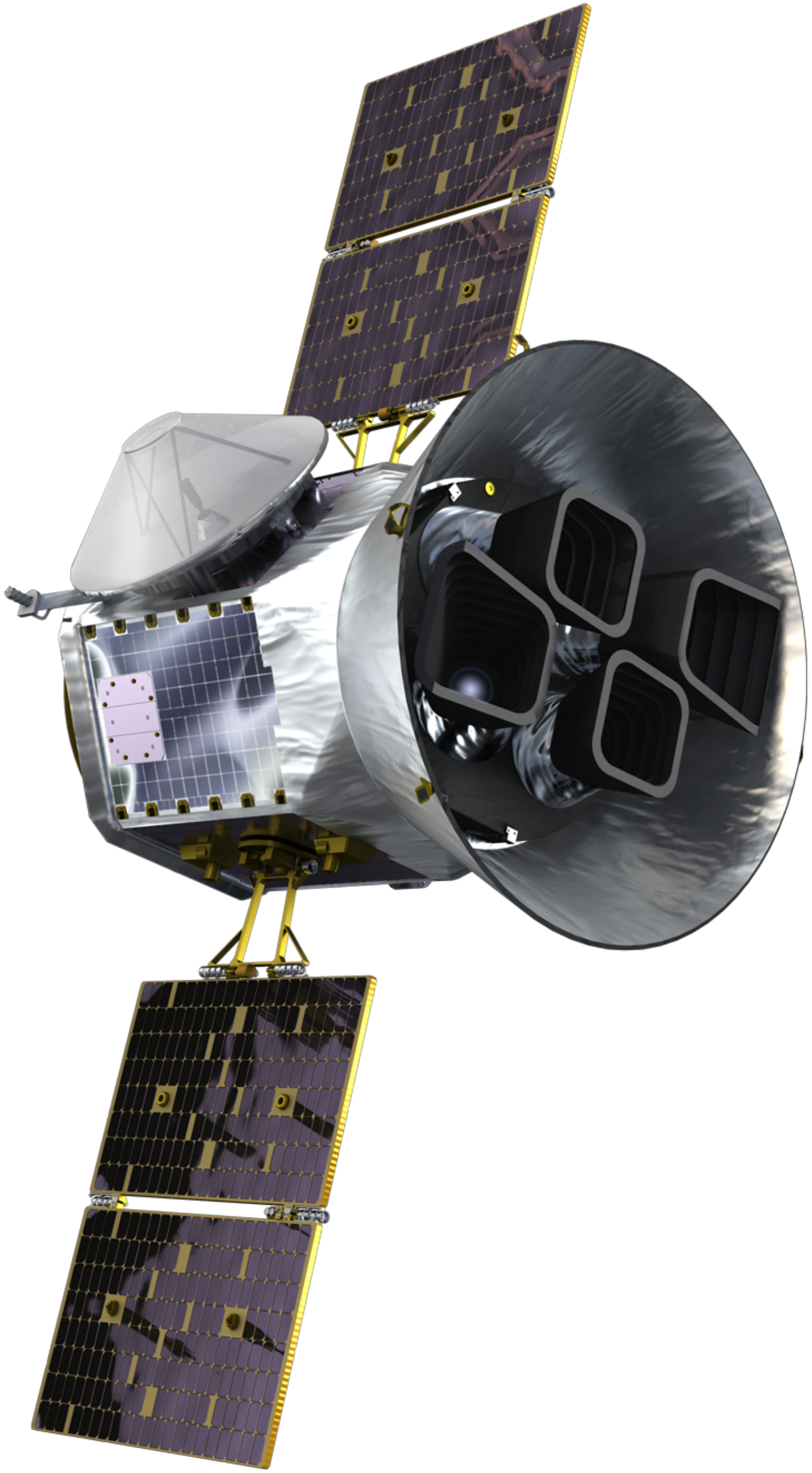
TESS Follow-up Observing Program will characterize the TOIs with recon spectroscopy, seeing-limited transits, high-resolution imaging, and precise radial velocities.

Cooperation and collaboration are key to make the most of our collective resources. NExScI is expanding the ExoFOP portal to coordinate community efforts on TESS.

K2 observers: *please use ExoFOP and provide feedback.*
You can shape the TESS follow-up process!

CHEOPS observes only one star at a time, but it has 9X the collecting area of TESS.

TESS Slides from Zach Berta-Thompson



Takeaways

- We need TESS to find nearby bright small transiting planets.
- TESS is coming to life and is on schedule to launch in 2017.
- The TESS planets will forevermore be the best small planet targets for radial velocity mass measurements and atmospheric characterization.

PLATO is expected to achieve precision better than 10 ppm

Table 2 Expected number of monitored cool dwarf and sub-giant stars with PLATO 2.0 in comparison to *Kepler*

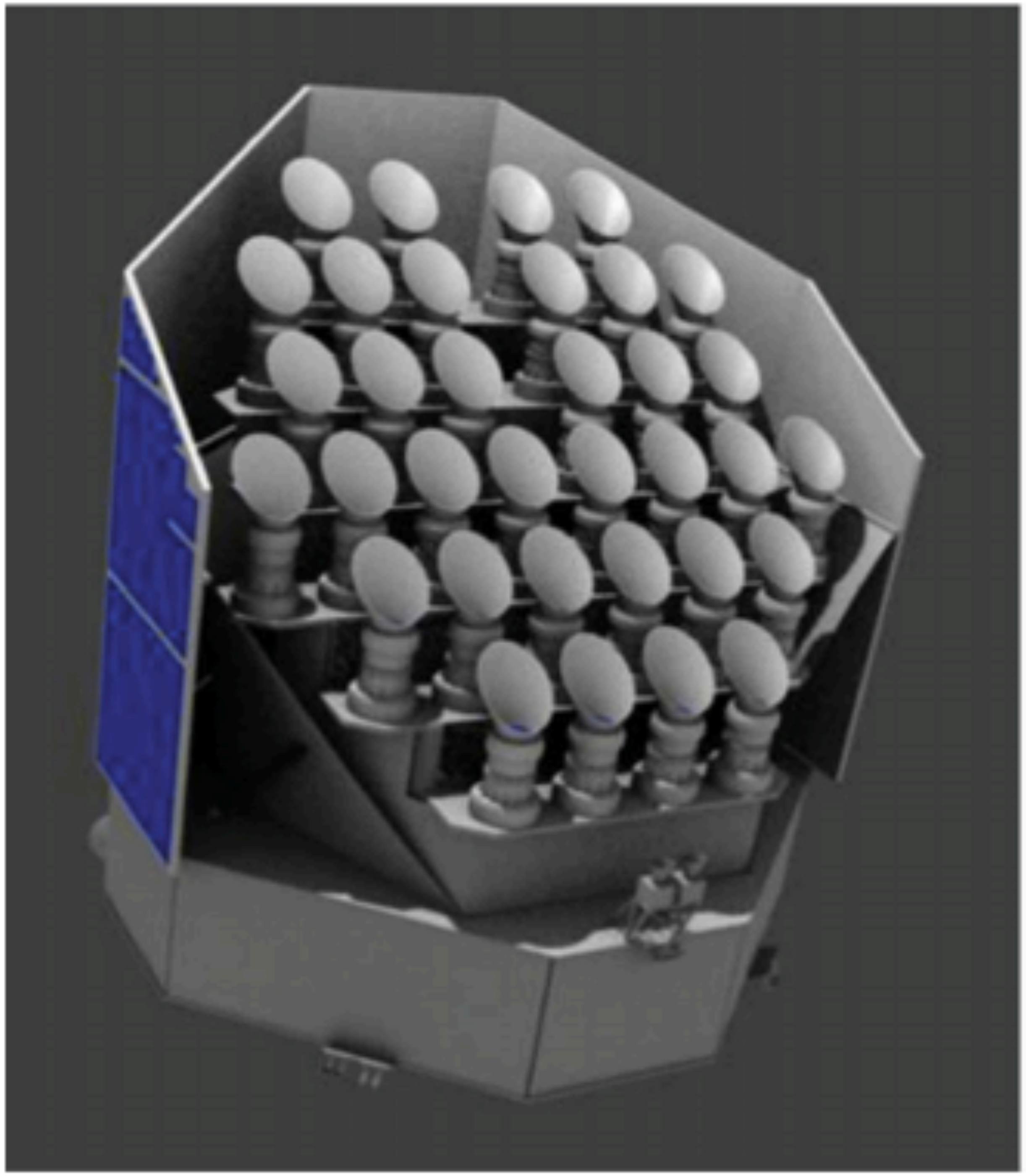
Noise level (ppm in one hr)	m_V	PLATO 2.0: 2 long pointings	PLATO 2.0: 2 long pointings + step-and-stare	Kepler: Fixed *Kepler* field
8	8	>1000	>3000	30
34	11	22000	85000	1300
80	13	267000	1000000	25000

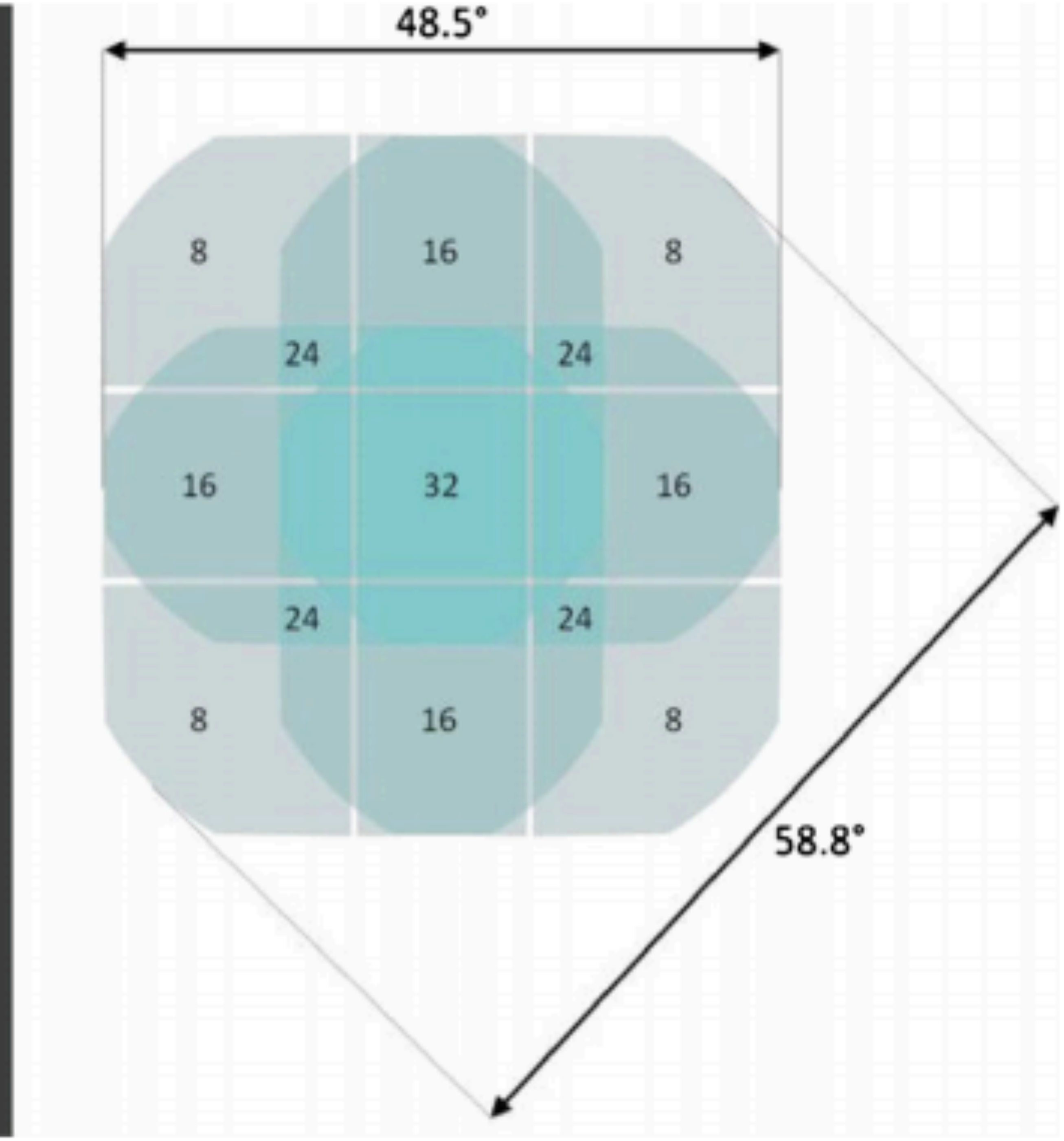
	PLATO 2.0
Magnitude range	- normal cameras: $8 \leq m_V \leq 16$ mag - fast cameras: 4–8 mag
Aperture size	- 32 × 12 cm normal cameras - 2 × 12 cm fast cameras
FoV	2232 deg^2 total (48.5° × 48.5°) - normal cameras: ~1100 deg^2 - fast cameras: ~550 deg^2
CCDs	- normal cameras: 4 CCD per camera 4519 × 4510px, 18 μm square, full frame, 15 arcsec/px - fast cameras: 4519×2255px, 18 μm square, frame transfer
Time sampling of data points (readout cadence)	- normal cameras: 25 s (~22 s exp. time) - fast cameras: 2.5 s (~2.3 s exp. time)

	PLATO 2.0
Spectral range	- 500–1000 nm (normal cameras) - one broad band for each fast telescope
No. of target fields	Step-and-stare and 1–2 long pointings
Observing period per target field	20 days–3 years
No. of dwarf target stars per pointing	~150,000[a]
Total no. of target stars over mission	>1,000,000[a]
No. of bright targets ≤ 11 mag	~85,000 stars total[a]

Rauer et al. 2014, Experimental Astronomy, 38, 249

PLATO will have a large field of view





Rauer et al. 2014, Experimental Astronomy, 38, 249