Comments on
WFIRST AFTA Coronagraph Concept

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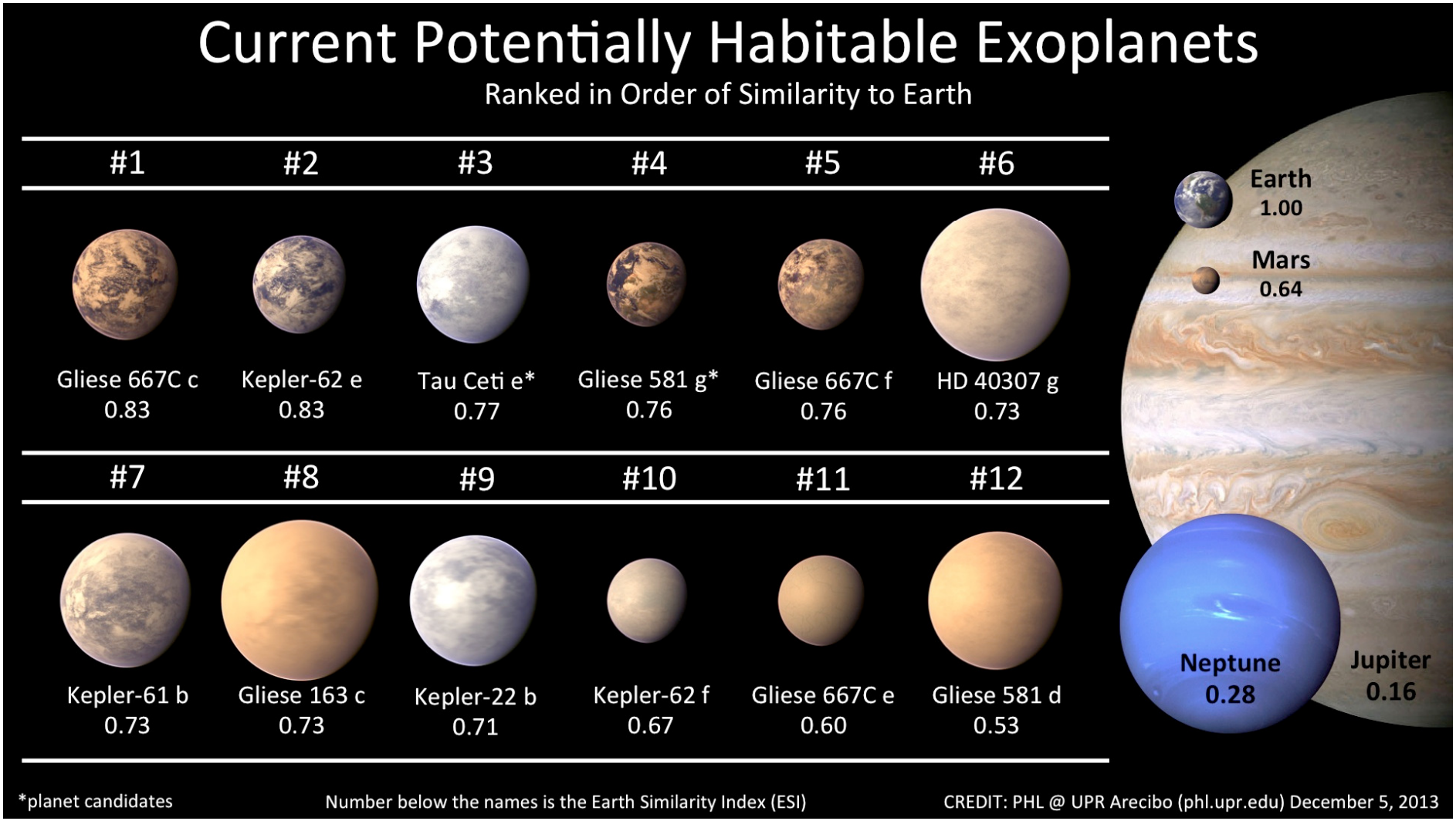
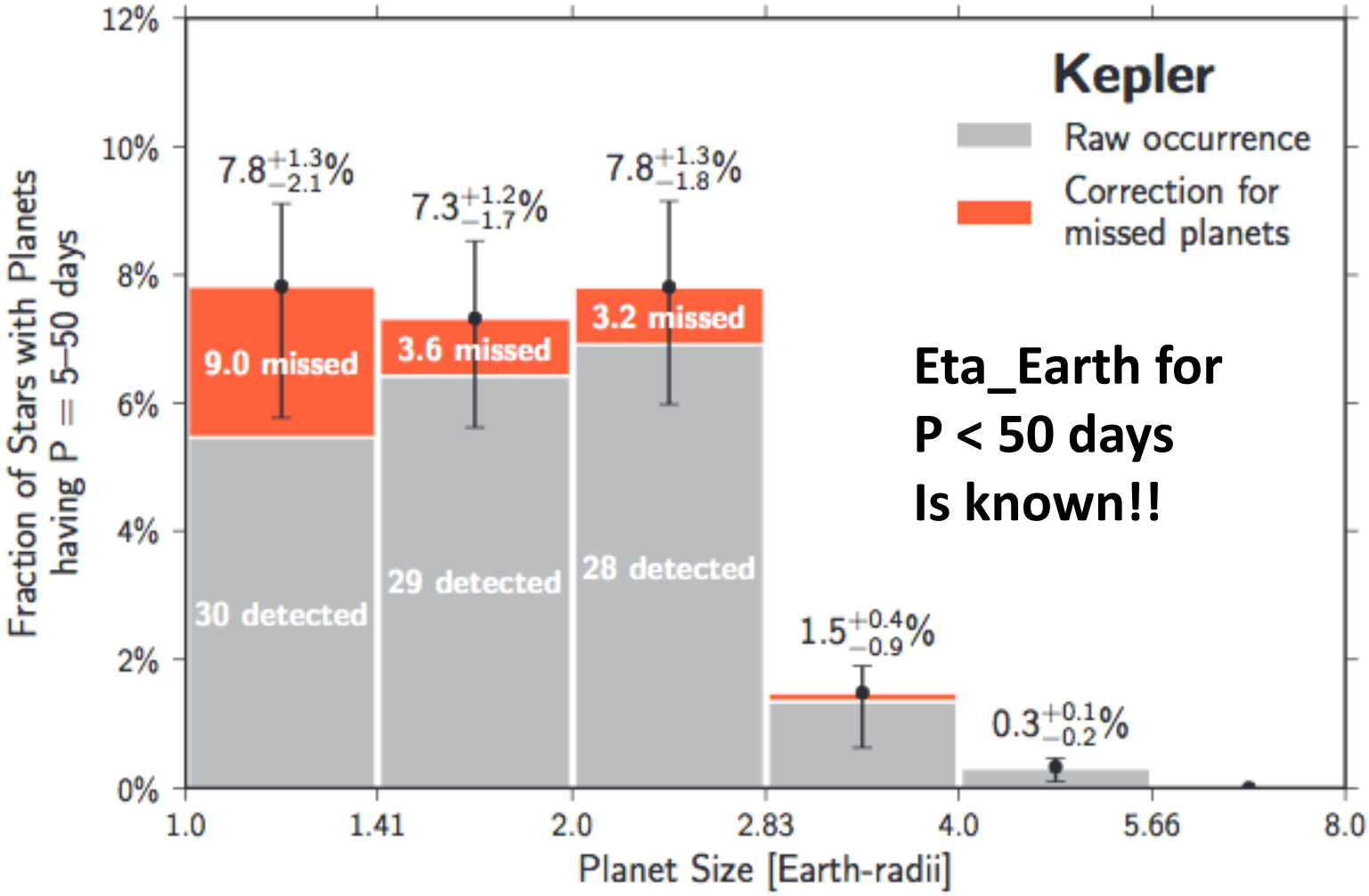
Exoplanet Science Has Changed Since 2010



35 Habitable Zone Kepler Planet Candidates known,
~12 confirmed planets (all but one discovered since 2010)

Exoplanet Science Has Changed Since 2010



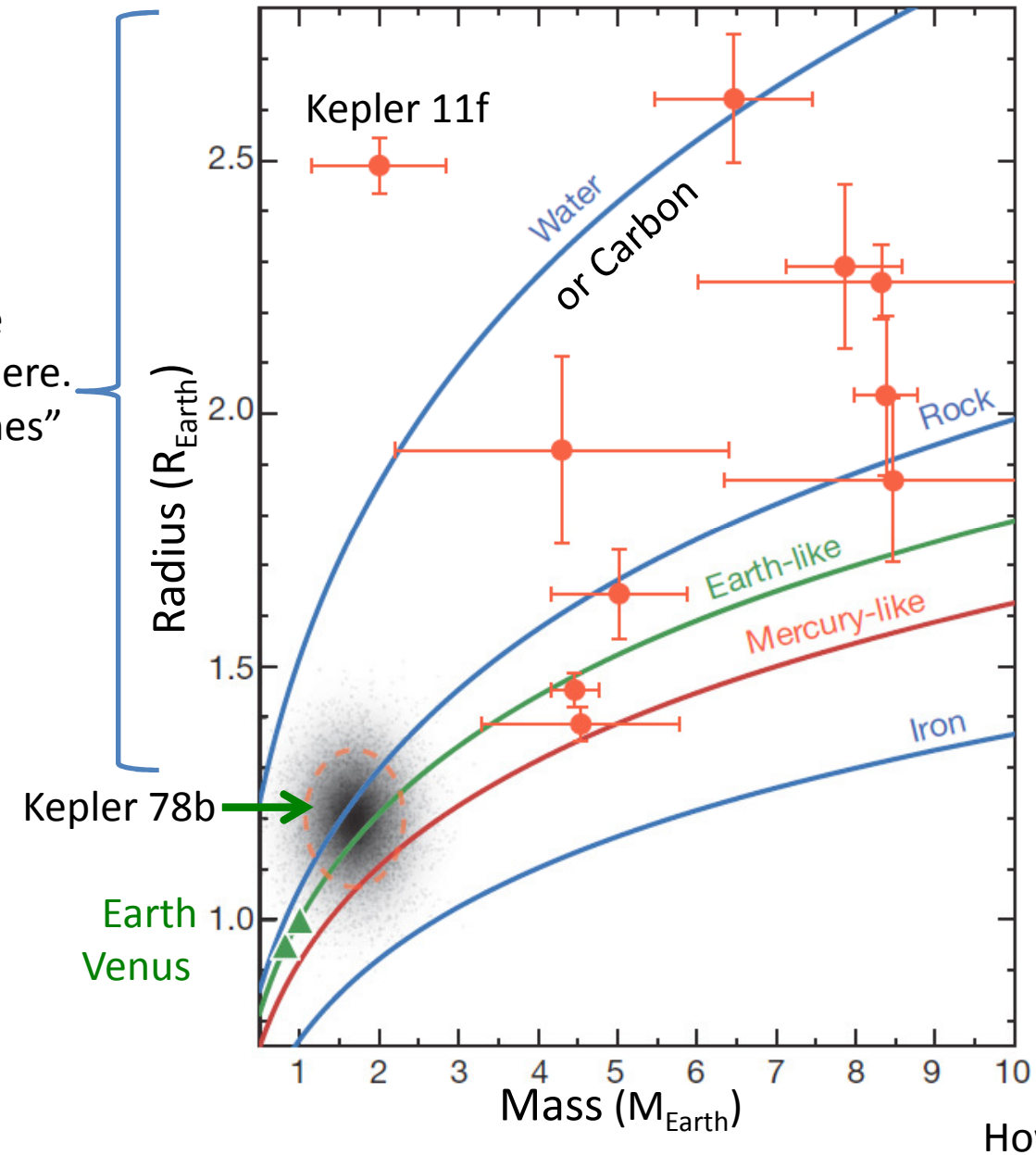
Eta_Earth for P < 50 days Is known!!

Note: Extrapolating to HZ remains tricky. Petigura et al. 2013 says "22% of Sun-like stars harbor Earth-size planets orbiting in their habitable zones." Ask Wes Traub for his take.

Petigura et al. 2013

Planet Densities/Compositions Are All Over the Map

Must have thick atmosphere. "Mini-Neptunes"

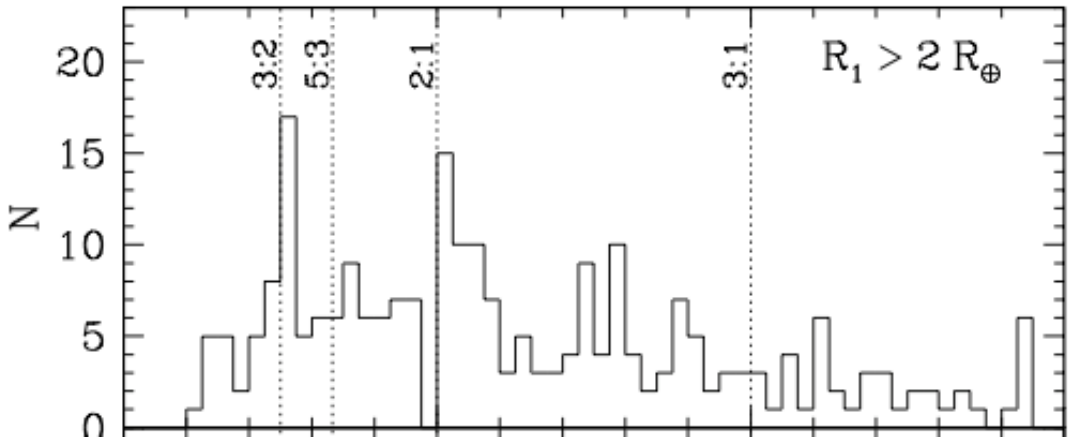


Alternatively, this range in density could all be explained by iron core + H/He atmosphere

Howard et al. 2013

First TTVS discovered;
Multiple Planet Systems are Puzzling

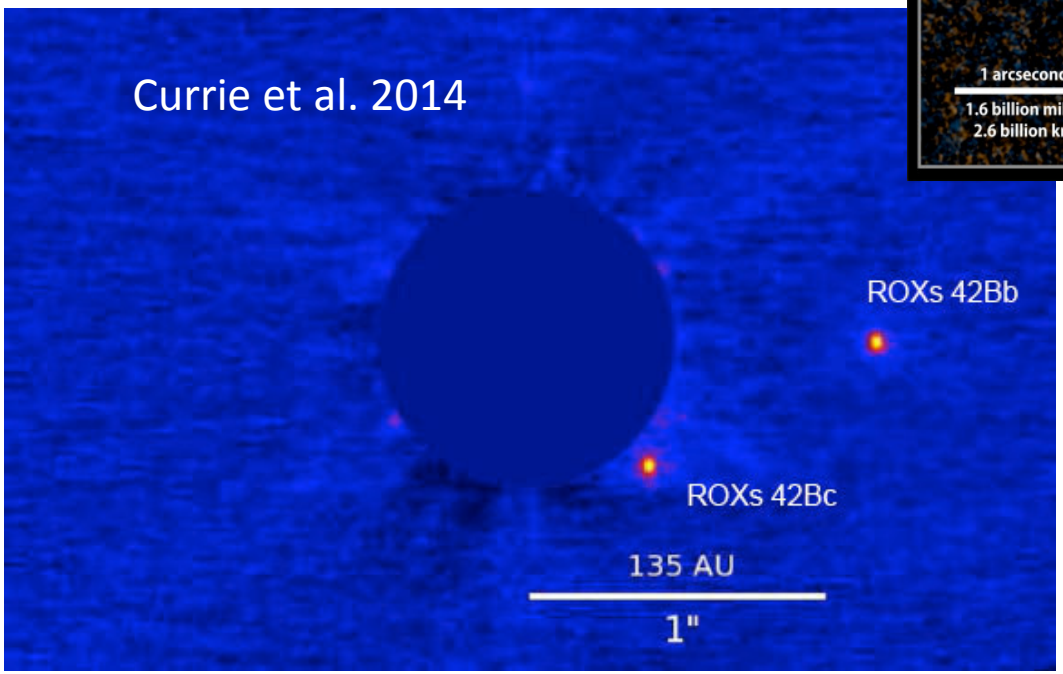
- 176 multiple planet systems now known
- 37 planets discovered through Transit Timing Variations (all since 2010)
- Multiple planet sytems found in excess just wide of resonances (Fabrycky 2012)

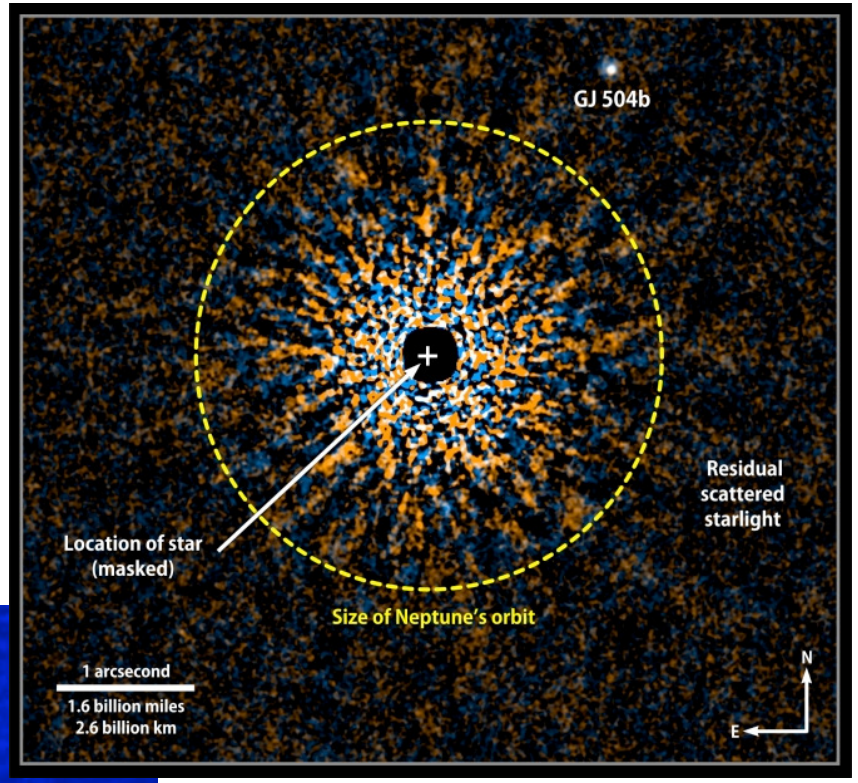


Direct Imaging Is Blossoming

17 Directly Imaged Planets
(10 new since 2010)

~6 associated with debris disks



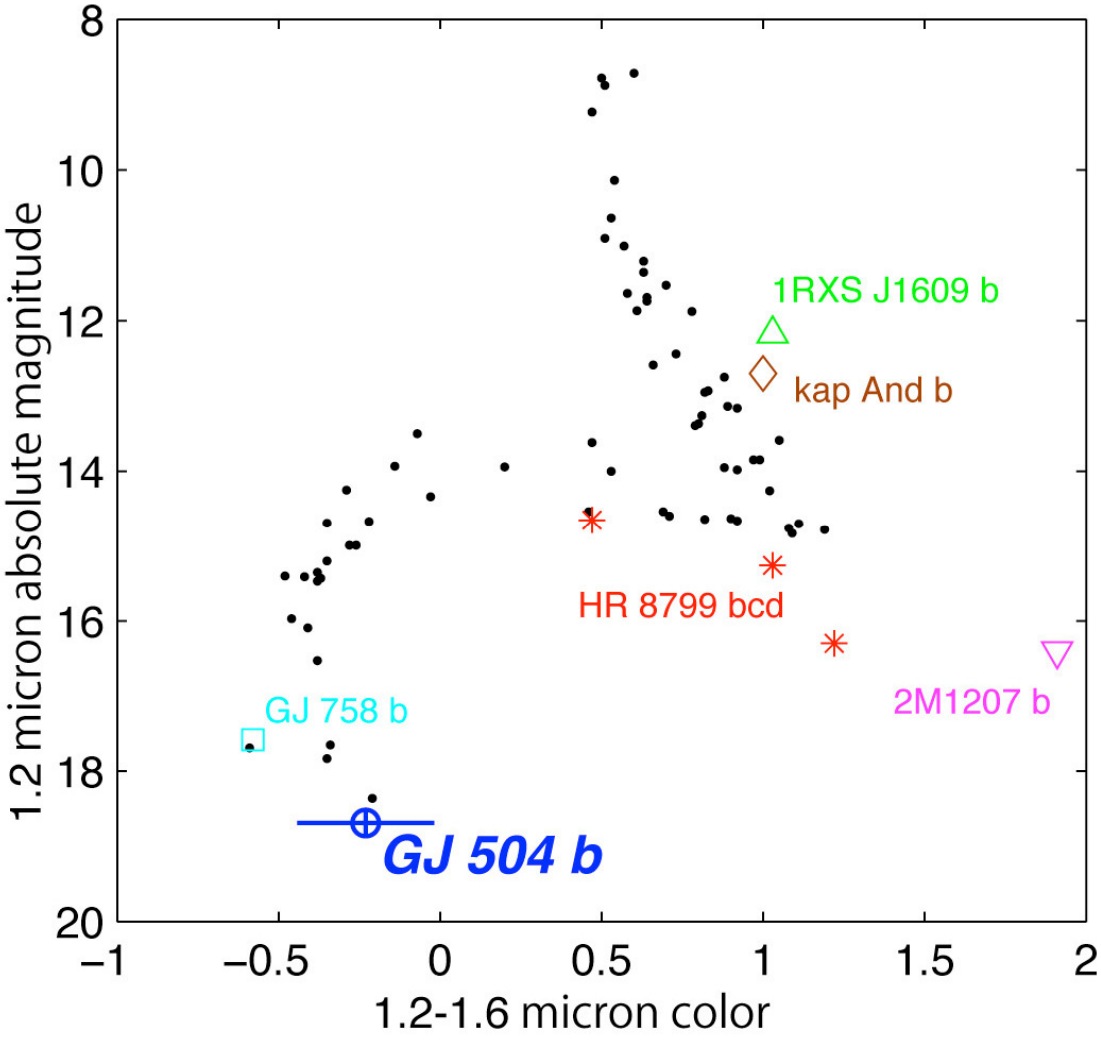


GJ 504b
Kuzuhara et al. 2013
3-8.5 Jupiter Masses

Multiband Direct Imaging Since 2010:

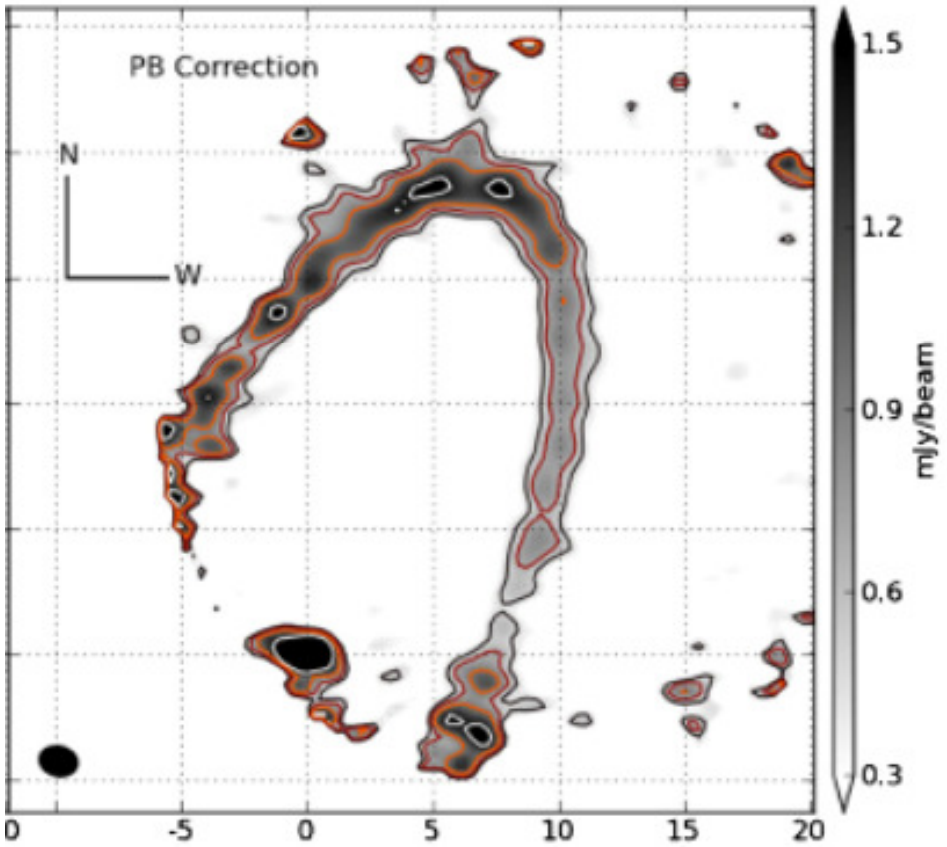
SOME Exoplanets show less CH_4 absorption than corresponding BDs.

Causes: clouds and non-equilibrium carbon chemistry



Credit: NAOJ

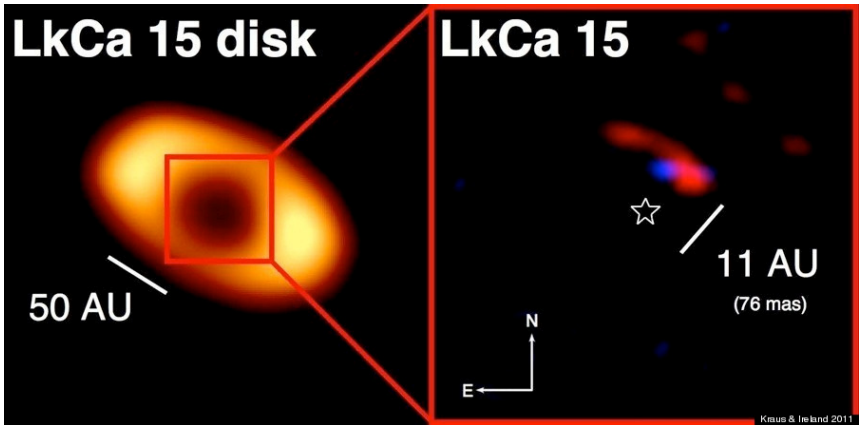
ALMA is making beautiful images of debris disks, showing us where the planetesimals are.



Fomalhaut
ALMA 850 microns
Boley et al. 2012

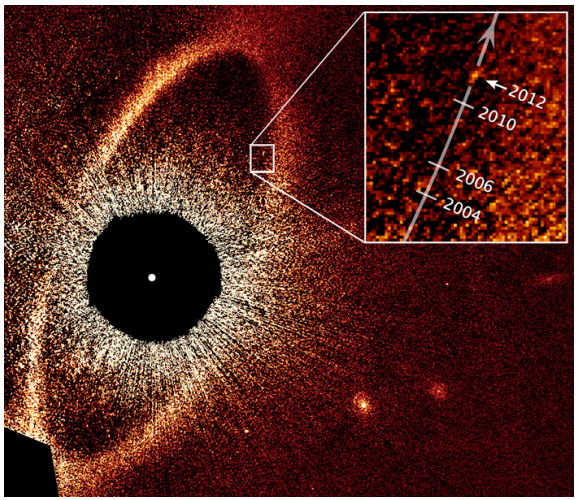
New Kind of Object: Planet Cocoons **(Placoons ?)**

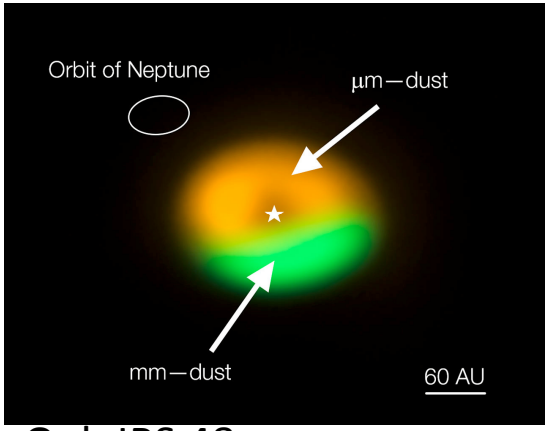
Planets, augmented by disk material.



(Kraus & Ireland 2011)

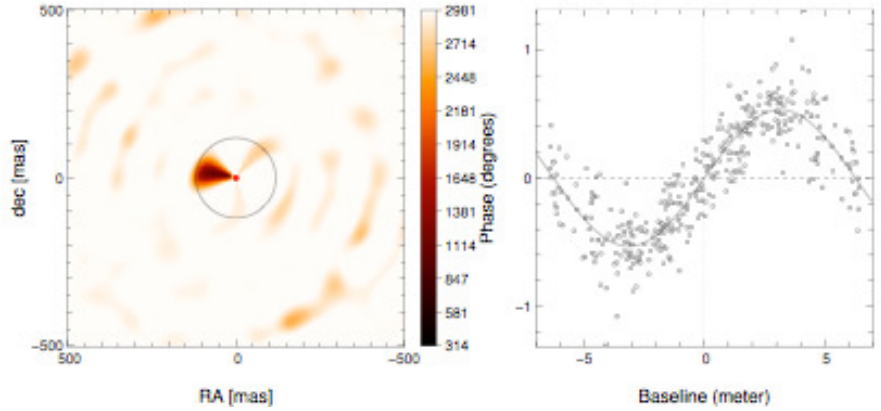
Fomalhaut b
(Kalas et al. 2008)
429 citations!) contrast: 10^9





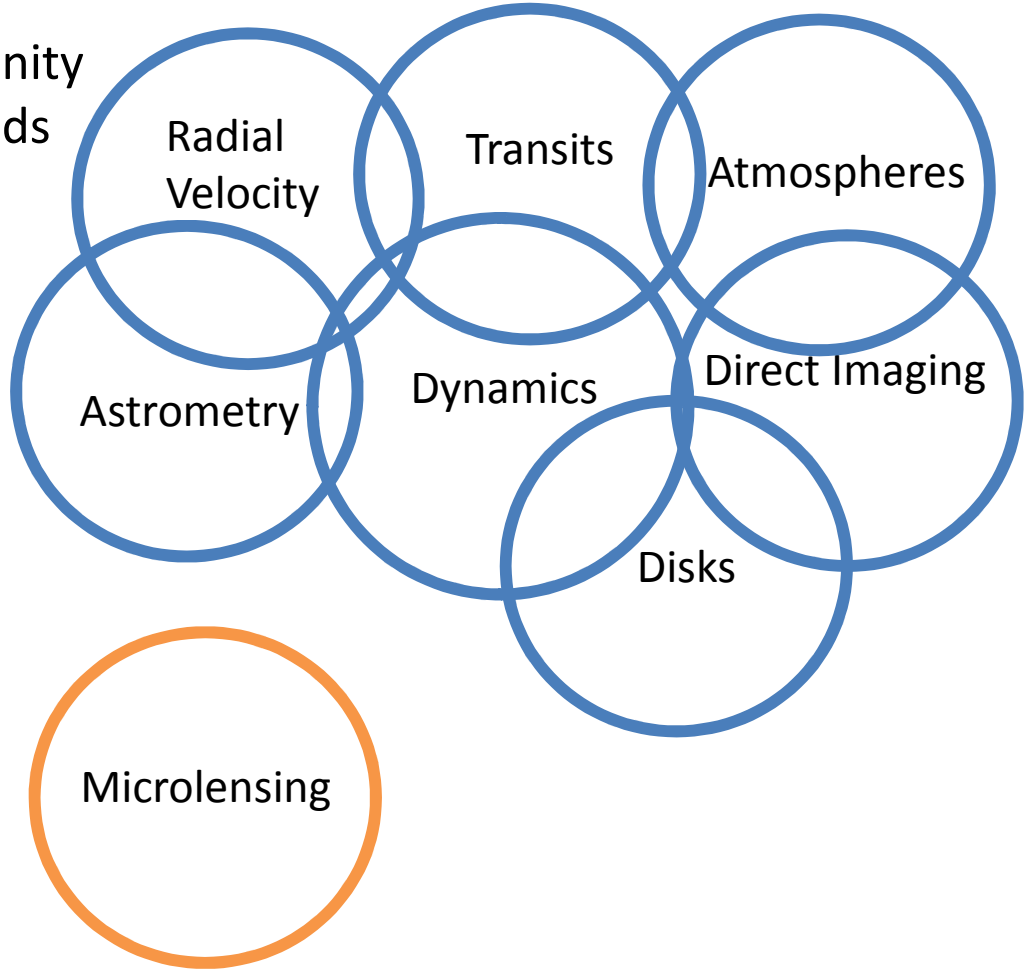
Oph IRS 48
(van den Marel et al. 2013)

T Cha b
(Huelamo et al.2011)



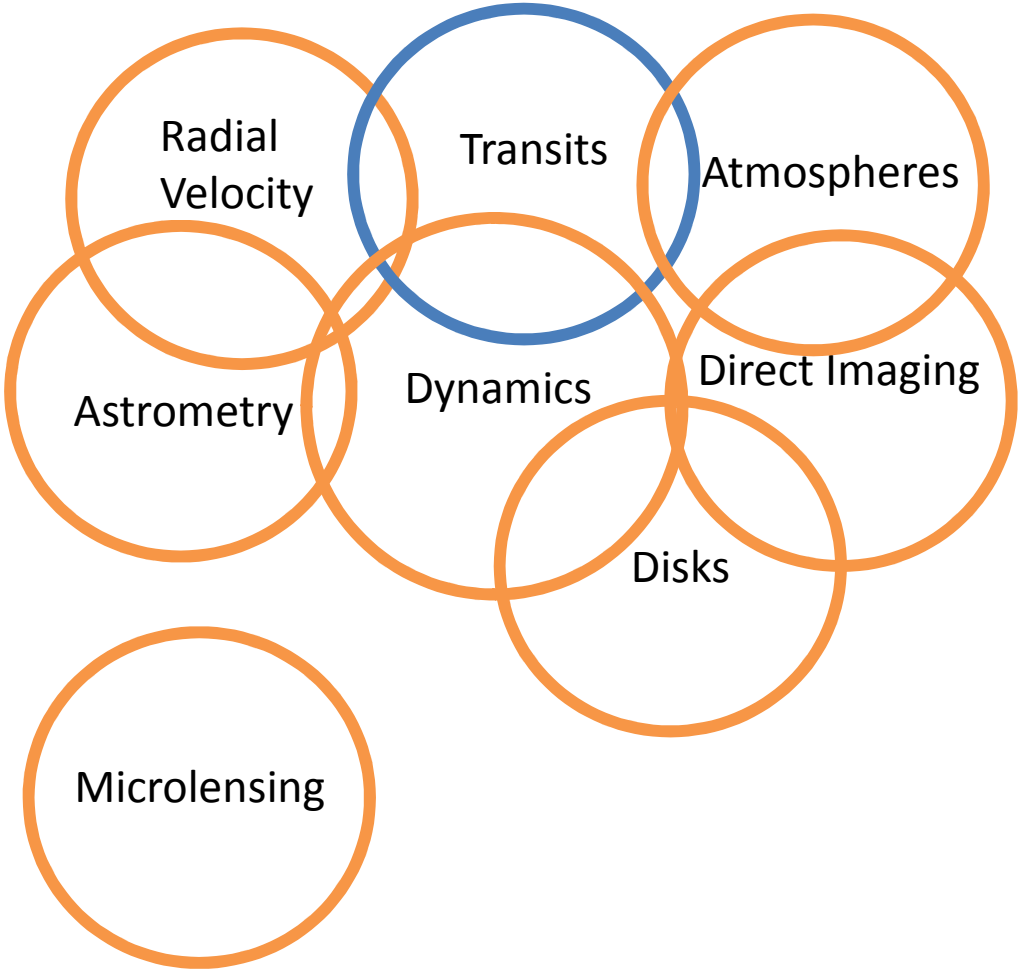
It’s time to reevalute the exoplanet science priorities.

Much of the Exoplanet Community was dissatisfied with New Worlds New Horizons 2010



Exoplanet Community

An AFTA Coronagraph can be a big step towards healing that.



Note: the Transit Community now has TESS ($210M/2017).

Exoplanet Community

To follow NWNH 2010—

To “enable a mission capable of studying nearby Earth-like planets to be mature for consideration by the 2020 decadal survey”

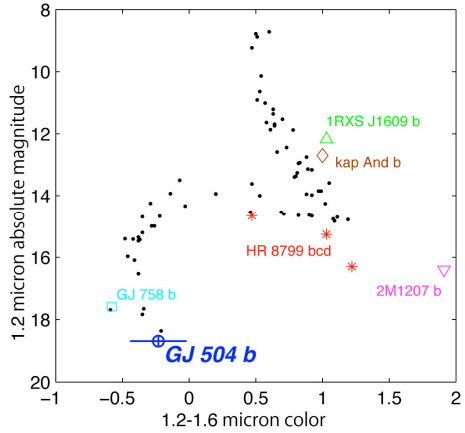
We need to test coronagraph technology in space.

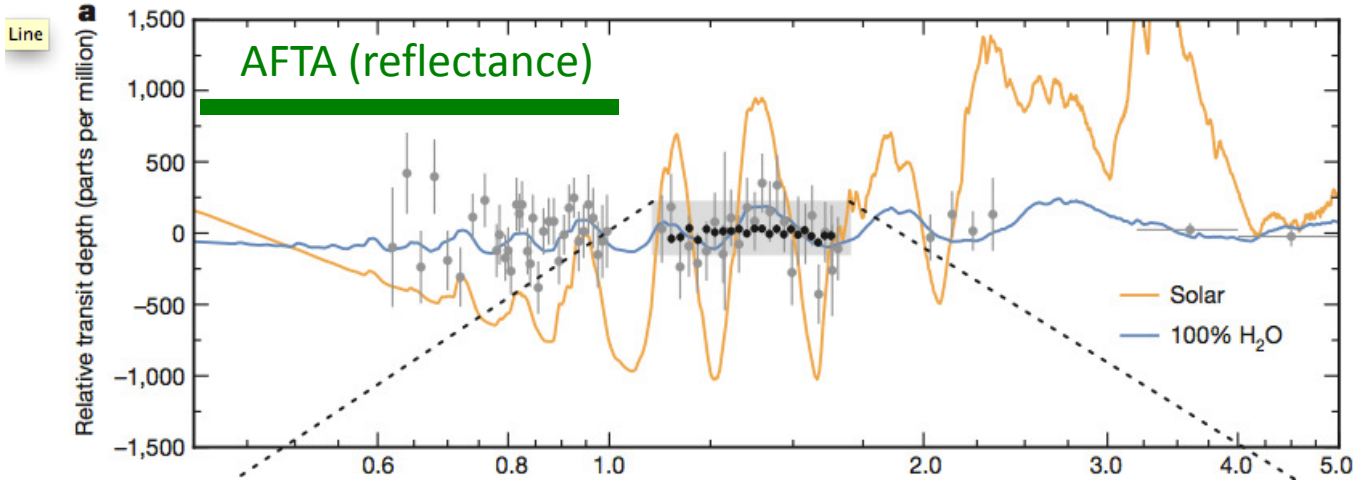
A probe mission to test the technology costs ~1B.

But a coronagraph instrument on WFIRST AFTA is much cheaper.

AFTA Coronagraph Science: Clouds, Chemistry

Make an exoplanet color-magnitude diagram in visible light





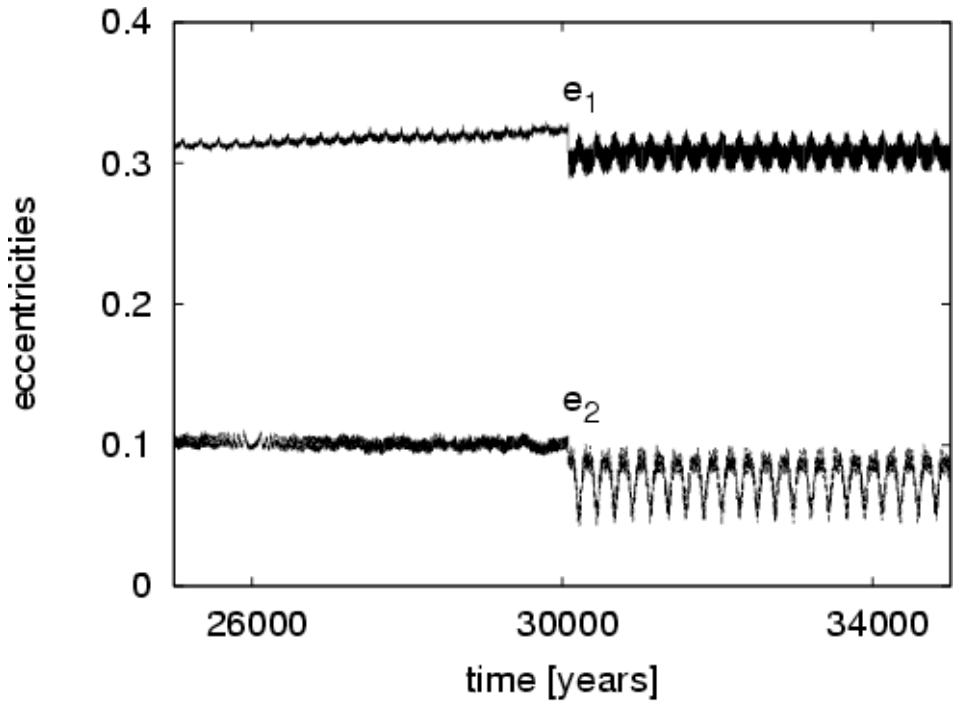
GJ 1214 transit spectroscopy w/STIS (Kriedberg et al. 2013)

Solar Composition, Water World, or Clouds?

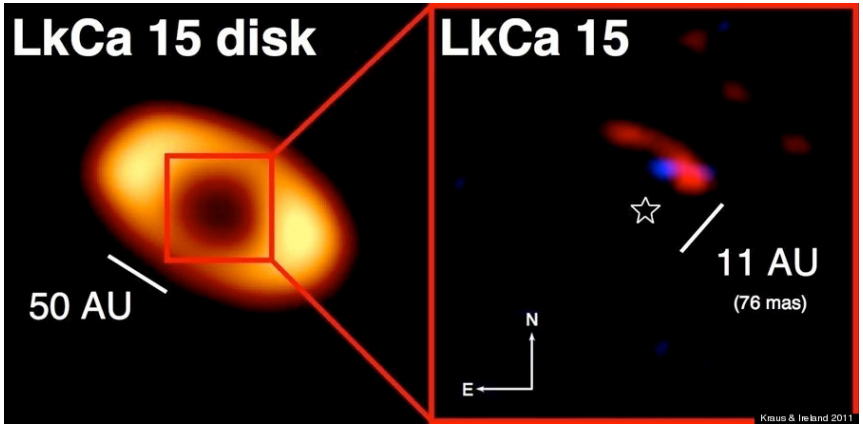
AFTA Coronagraph Science: Dynamical Habitability

We need to know where the Giant Planets are around TPF target stars to determine if the Habitable Zone is stable at low eccentricities.

AFTA Coronagraph can tell us.



AFTA Coronagraph Science:
Planet Cocoons **(Placoons ?)**



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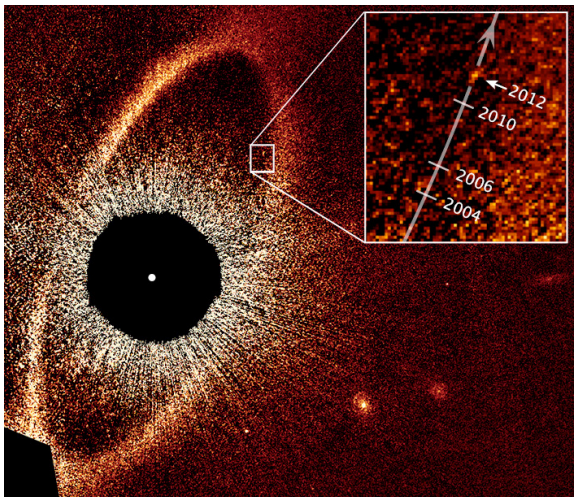

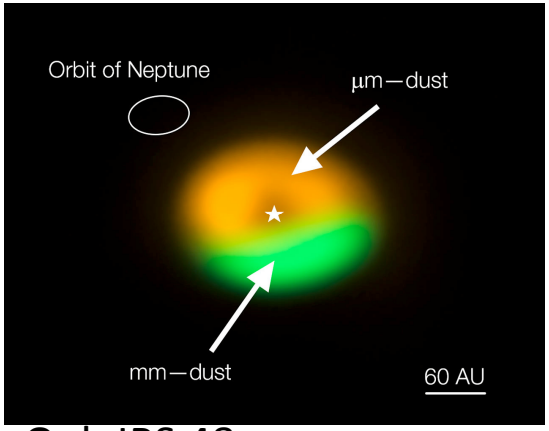

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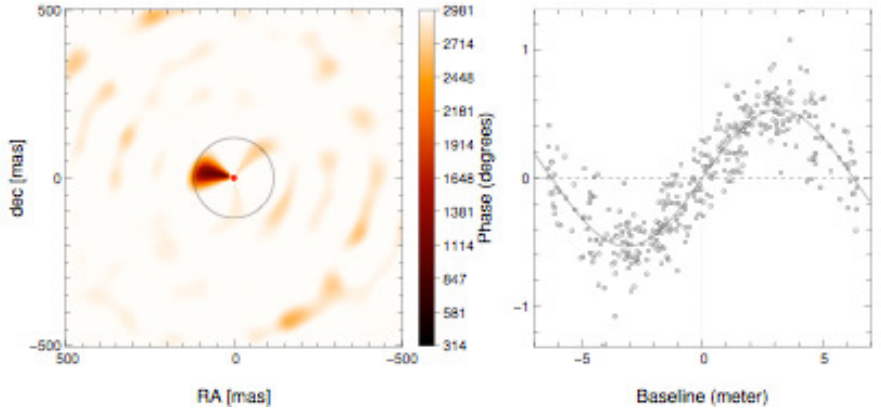
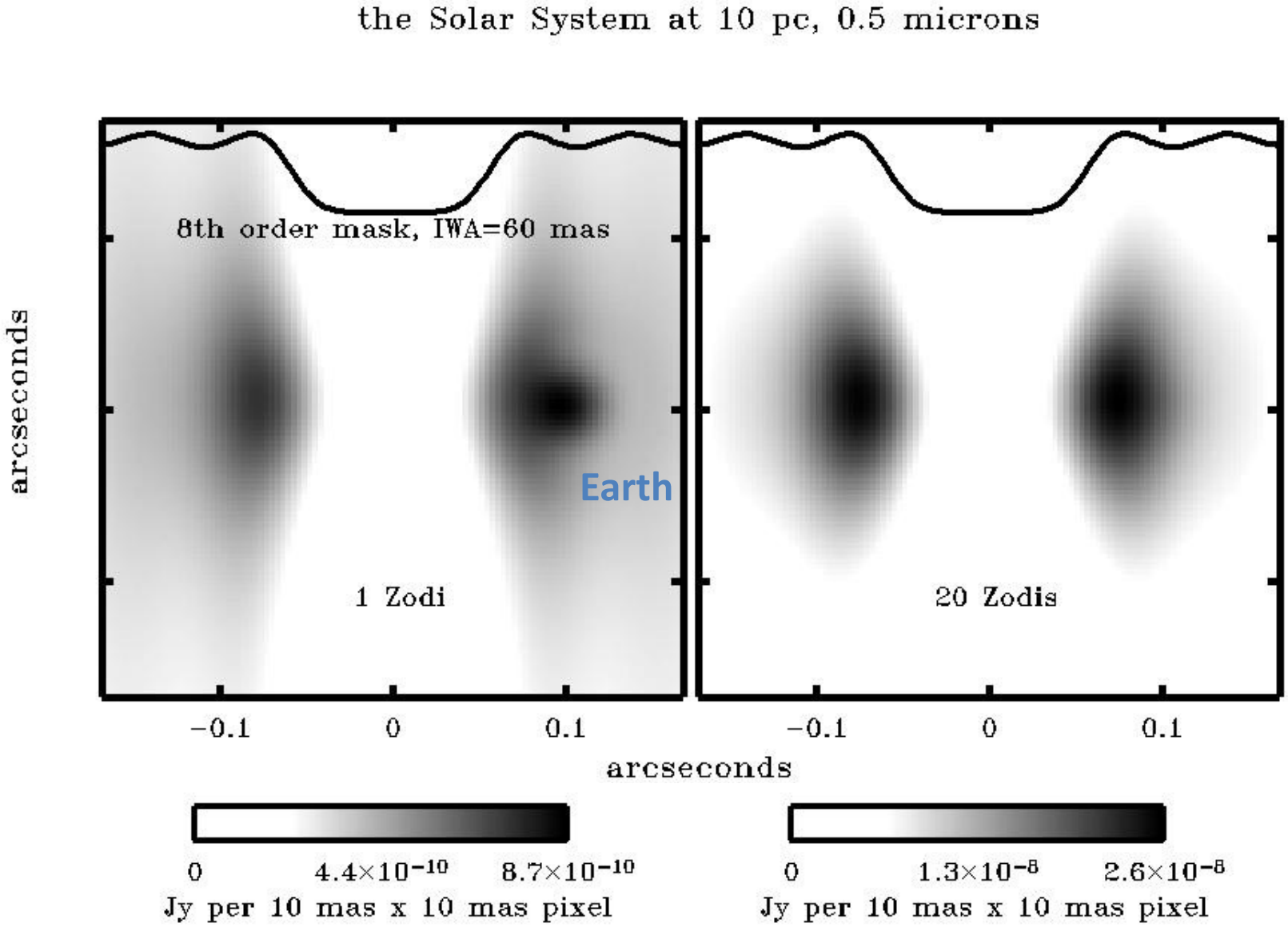


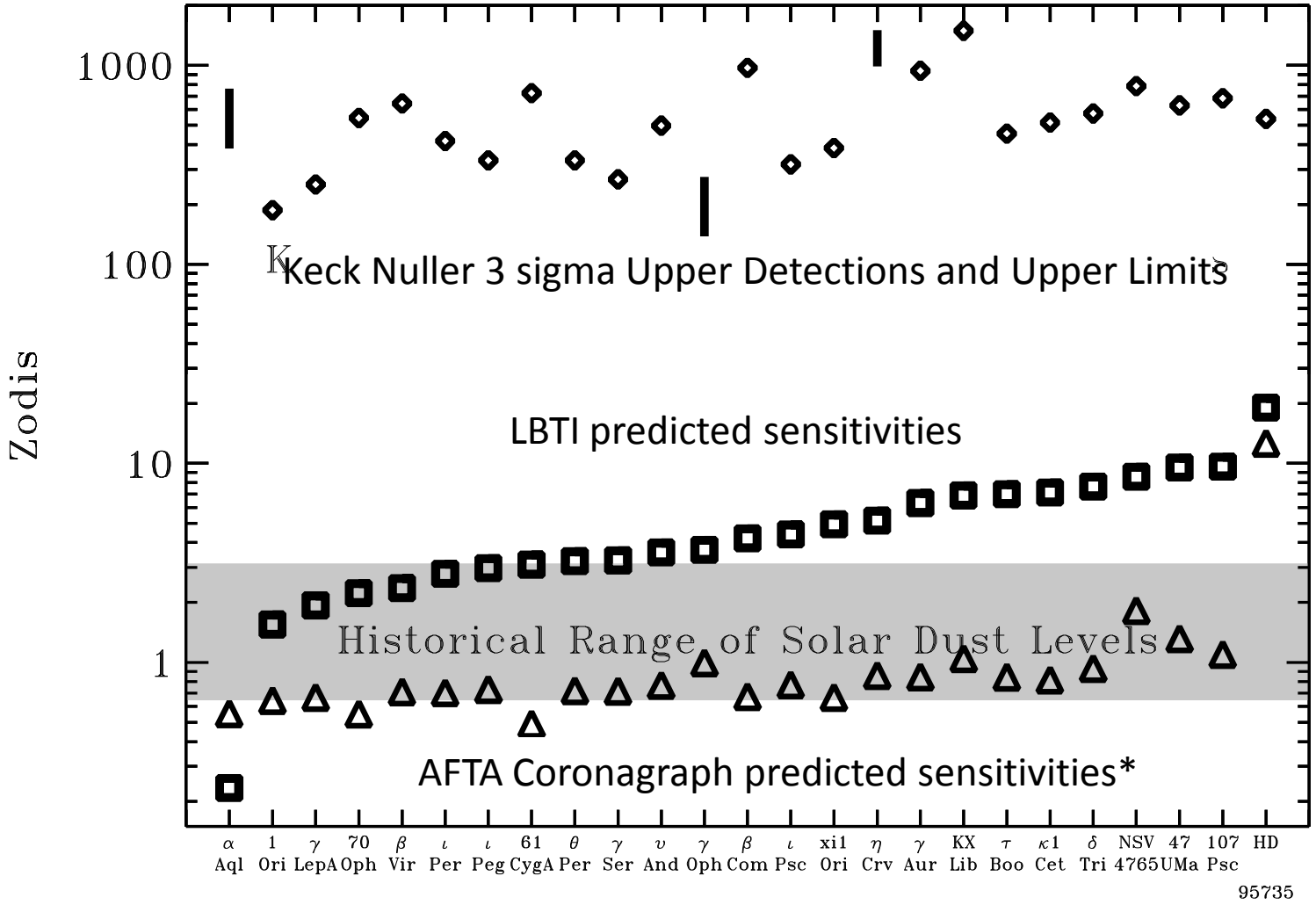
How Exozodiacal Dust Affects 10m TPF



Simulation by Marc Kuchner 1/13/14

AFTA Coronagraph Science:

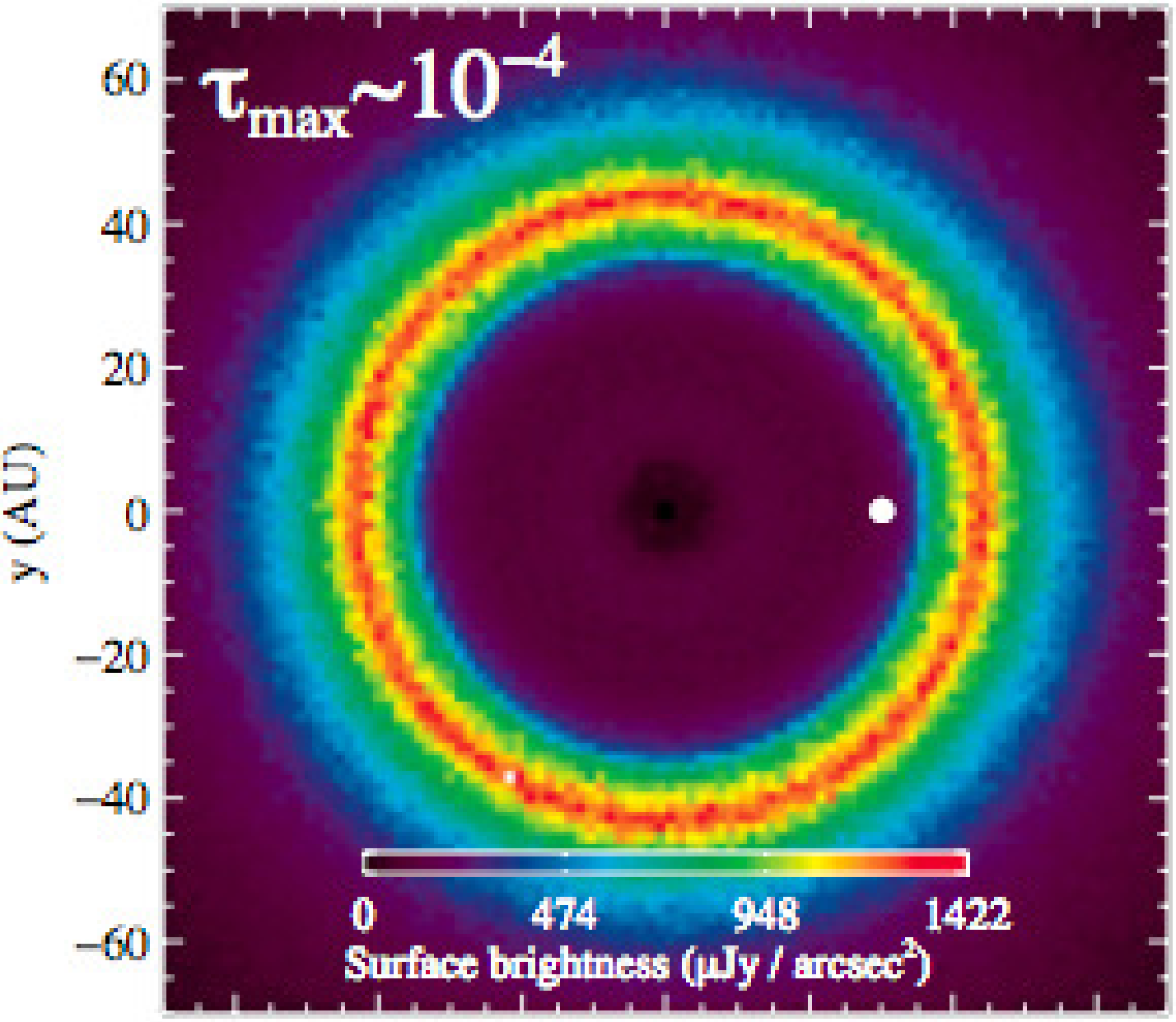
An ExoZodi Survey more sensitive than LBTI, around later-type stars.



assuming *10^{-10} at 150 mas

Simulation by Marc Kuchner 1/13/14

Disk Structure Predicted to Change With Zodi Level

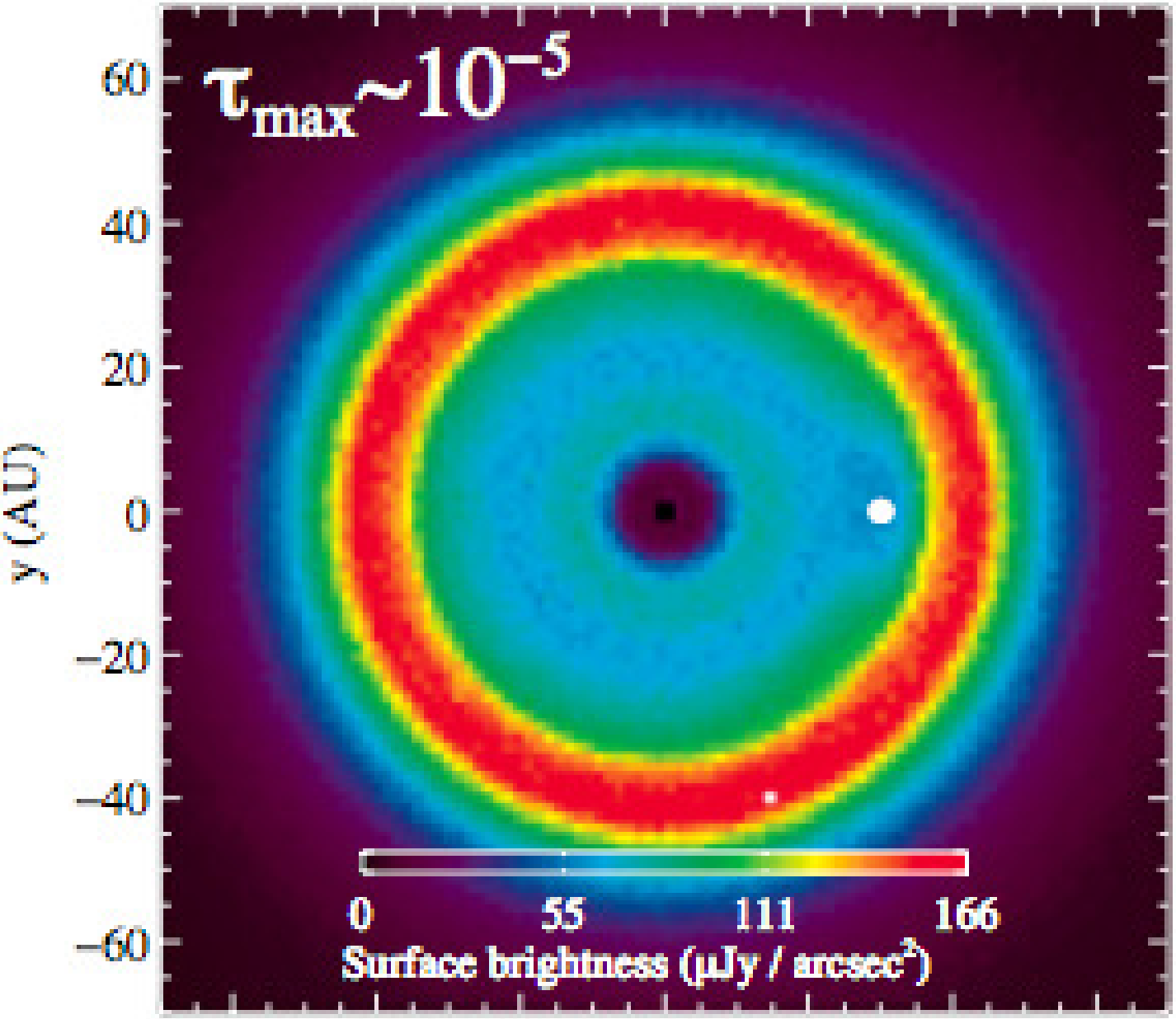


Kuiper Belt Model

Kuchner & Stark 2010

AFTA Coronagraph Will Test This

Disk Structure Predicted to Change With Zodi Level



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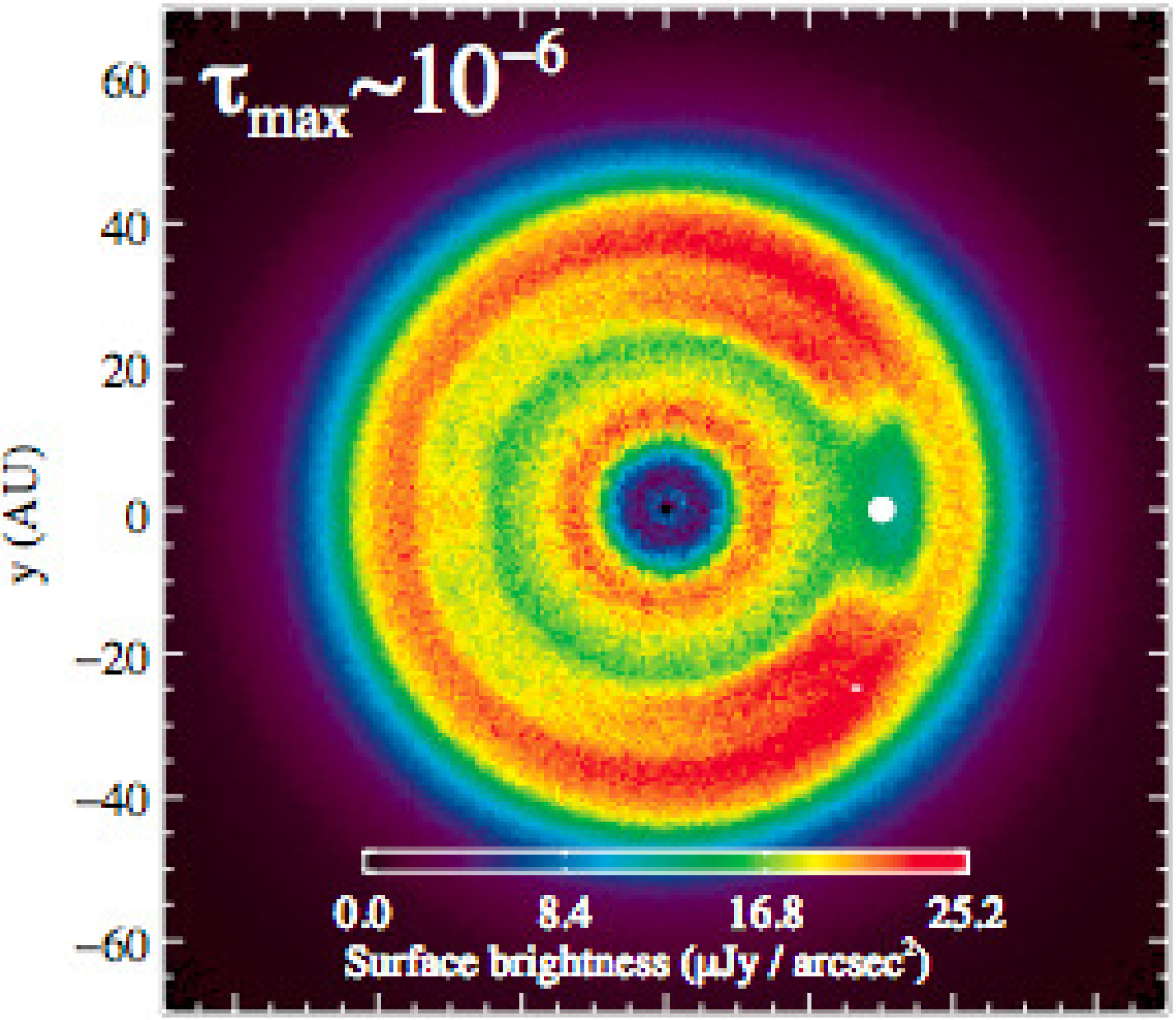

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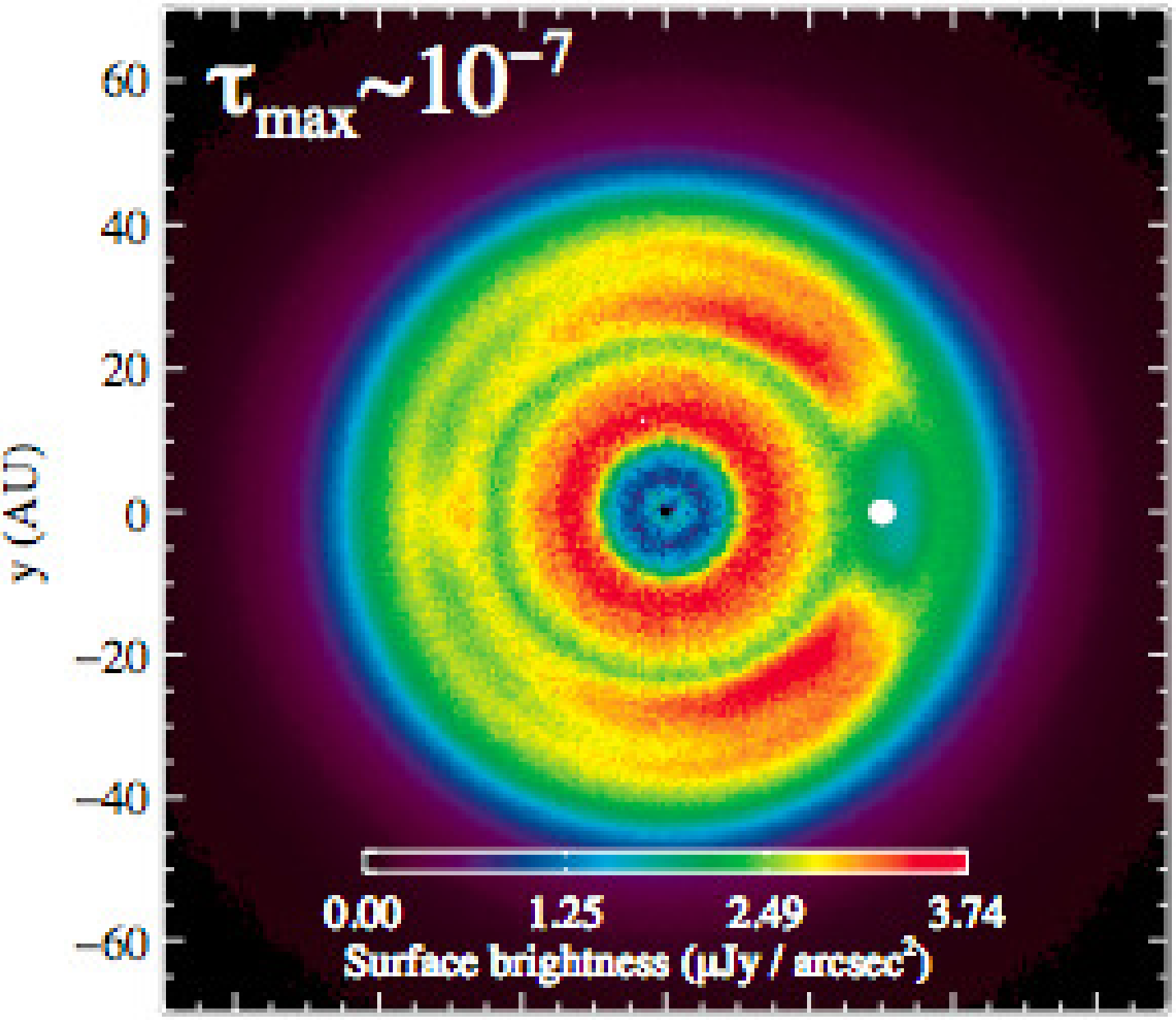


Kuiper Belt Model

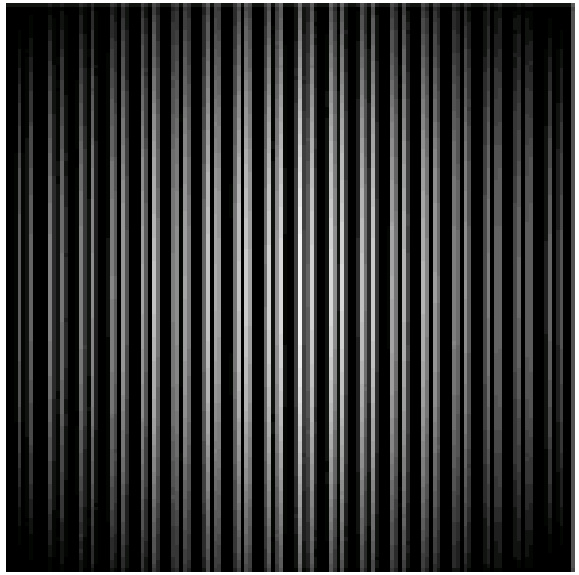
Kuchner & Stark 2010

AFTA Coronagraph Will Test This

Possible Counterargument:

Technology downselect might have been too early.

e.g. Rick Lyon has been out sick.



However, the TDEM program will continue to develop these other techonologies.

AFTA Coronagraph tests the wavefront control technology—the hard part.

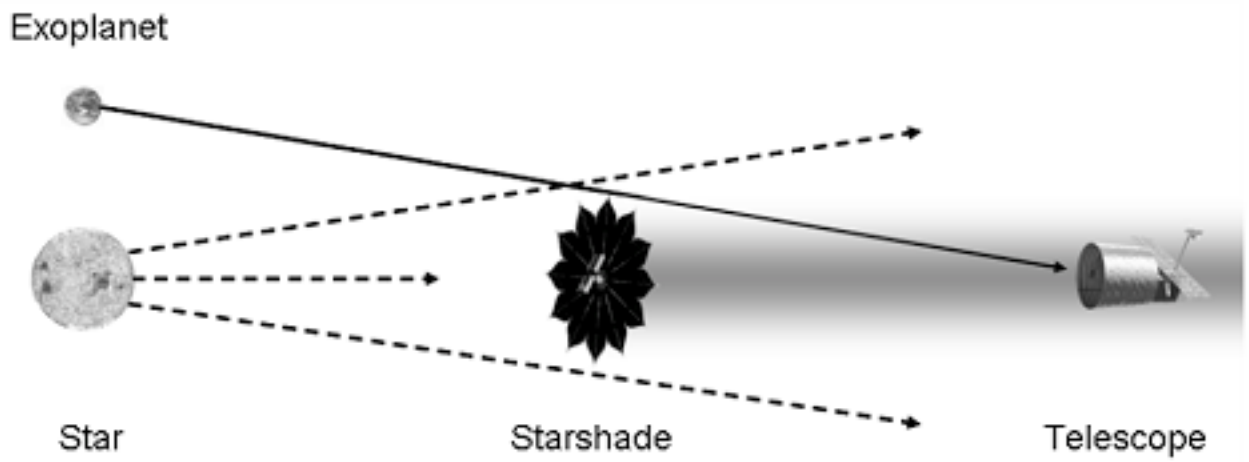
And the VNC in particular is the most decoupled from the wavefront control (doesn't use ACAD).

Possible Counterargument:

AFTA Coronagraph does not help mature Starshade technology, which has the advantage of being intrisically broadband/large search area.

However, the starshade is not amenable to this kind of ride-along test.

And we'll be continuing to advance it through TDEM.

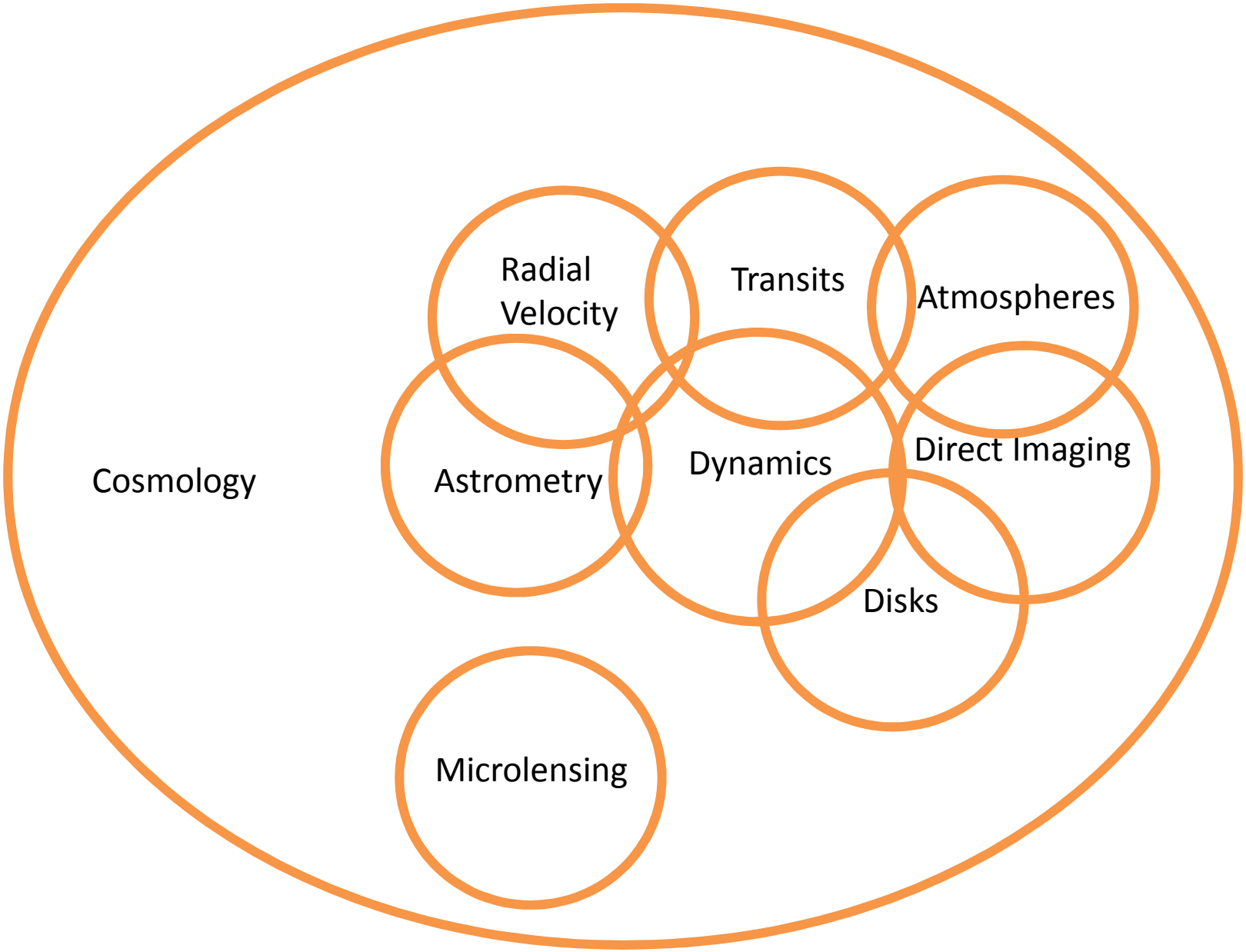


AFTA Coronagraph is a crucial technology development investment
if we want to have hope of building a future exo-Earth imager in my lifetime.
Will advance all these technologies **common** to all TPF coronagraphs,
which need to be proven in space:

Reliable, small element DMs
End-to-end control with a real large mirror, IFS with on-orbit degradation
Low-order wavefront sensing
Instrumental scatter/stray light
Low read-noise detectors
Polarization issues---I hope
Zodiacal light around late-type stars

Will also help with ground-based telescopes, and future generations
of space telescope.

Jeremy Kasdin's, John Trauger's talks.



New Exoplanet Community Thanks to AFTA Coronagraph