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University of Colorado, Boulder
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EXOPAG, Kissimmee, FL

We Need to Get Behind a Starshade Mission Now!

Our Colleagues at NASA are on the verge of making this happen.

We should unequivocally endorse that a mission to spectroscopically search for biomarkers on exoplanets

The Europa Mission Has a Lander!

This was announced in the recent budget.

NASA HQ had not asked for this.

What happened?

Are there lessons for us, the exoplanet community?

Q&A: John Culberson's unique vision for science

Jeffrey Mervis *SCIENCE INSIDER*
22 December 2015

Representative John Culberson (TX-07) is Chair of the House Subcommittee on Commerce, Justice, Science Appropriations which oversees the Department of Commerce, the Department of Justice, the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and other related agencies.
He is just completing his first year in this post.

Q: Is 2016 a high-water mark for science because of the additional funds available in the 2-year budget agreement? And are you worried that 2017 will be flat and you won't be able to continue these new initiatives or even preserve current levels of activity?
A: I'm a zealous advocate for scientific research and space exploration, have been my whole life. And I will continue to be a passionate and aggressive advocate for NASA and [NSF] to ensure that America's position as the world leader in research and space exploration is unchallenged. I'll do whatever it takes to make sure that America stays number one in the world, protecting the high ground in space and our leadership in cutting-edge scientific research.

Q&A: John Culberson's unique vision for science

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Q: Turning to NASA, you boosted spending for the Europa clipper mission $35 million higher than the House's earlier level, to almost six times the administration's request of $30 million. What do you hope to achieve with that extra funding?

A: The Jet Propulsion Laboratory [JPL] is absolutely confident that they can achieve the goals of the decadal survey recommendation for this top priority mission with an orbiter and a lander. The goal here is to discover life on another world. That's the reason the Europa mission has been the top priority of the past two decadal surveys.

The scientific community agrees that the place with the greatest chance of harboring life outside of Earth are the oceans of Europa. I have been briefed extensively on the planning and design of the mission. It's obvious that the only way to confirm there's life in the oceans of Europa is to land on the surface and sample the ice. And JPL and Ames [Research Center] can do that, based on their experience with the Mars landings.

The United States is uniquely qualified to accomplish a challenging landing like this. And the scientists and engineers at JPL are absolutely confident that they can carry it out successfully.

The [U.S. National Academies of Sciences, Engineering, and Medicine] decadal surveys recommended this mission because it's the project most likely to be the first to identify life from another world. And when the engineers and scientists walked me through it, it's obvious that the only way to accomplish that goal is to land on the surface and test the ice.

Culberson (continued)

So why do the mission unless you are going to land on the surface and confirm that there is life on another world? That will be a transformational moment in human civilization, much larger than Neil Armstrong's stepping onto the moon. That is wh I'm so passionate about the Europa mission. Europa has had no advocate, until now. And I know in my heart that there is life on other worlds, and that we will most likely discover it in the oceans of Europa. And that moment will galvanize public opinion, transform our view of the universe, and the American taxpayers will be ready to take NASA up to the next level. So if we are going to return NASA to the glory of the Apollo era, in the short term, and allow NASA to seek out new life, it's going to require a transformational moment that will encourage people to support NASA at the necessary level, and that will be the discovery of life in another world, and that will occur in the oceans of Europa.

NASA has neglected Europa for too long. It has always funded and flown the flagship missions of the decadal surveys, until recently under the Obama and the Bush administrations, when they neglected the Europa mission.

In this bill, I also created an Ocean Worlds Exploration Program. This first Europa mission will be part of a bigger and broader set of missions to explore the oceans of Encelades and the seas of Titan, and beyond. And we will need the heavy lift capability of the [Space Launch System] rocket for all of those missions.

Exoplanets are Better than Europa

Habitable Planets
No possibility of Cross-Contamination

Lots of places to look
More like the one place we know has life

More resonant with the taxpayers

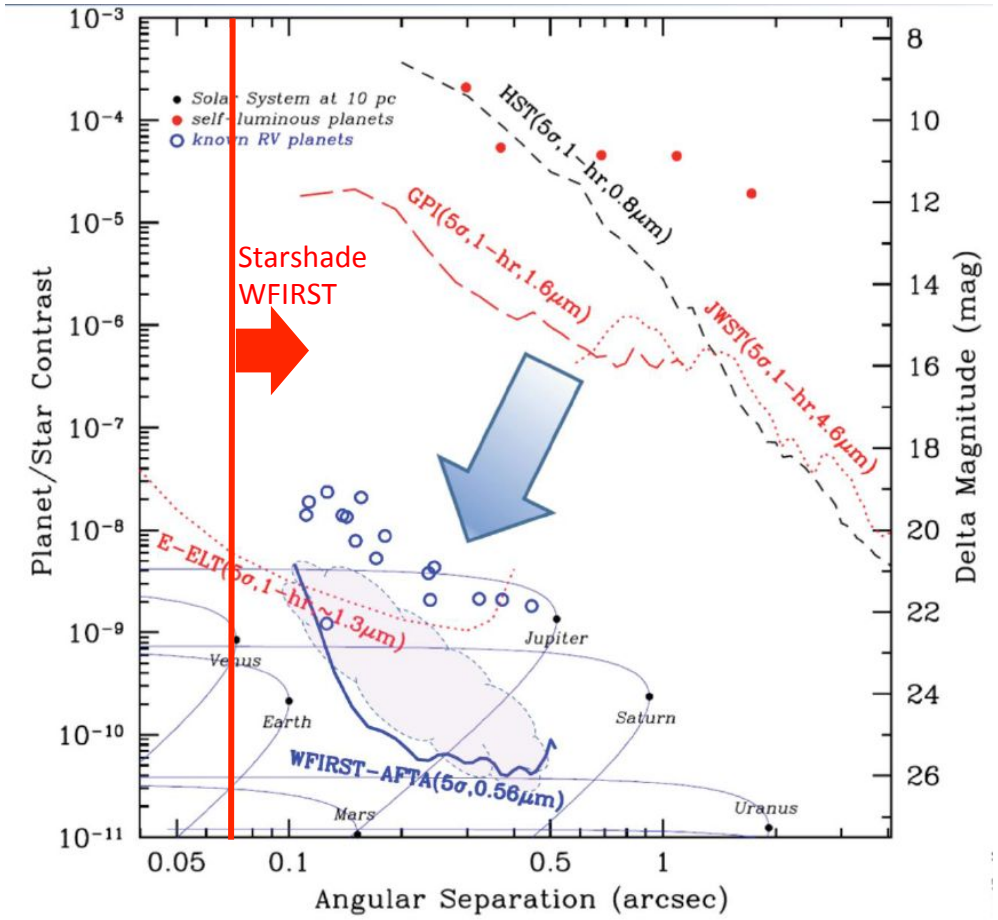
So what will it take to maintain leadership in the search for life outside the Solar System?

Planned Imaging Missions

In the adjacent diagram one can see that the internal coronagraph on WFIRST will be able to detect the Earth at 6pc when it launches – scheduled for 2025.

The ELT, from the ground, will start to see major planets at 5pc.

NASA is finally seriously considering adding a starshade to WFIRST. One can see why. Although it would cost ~$700M, it would provide a clear, high contrast view of the solar system, including the Earth out to 14pc.



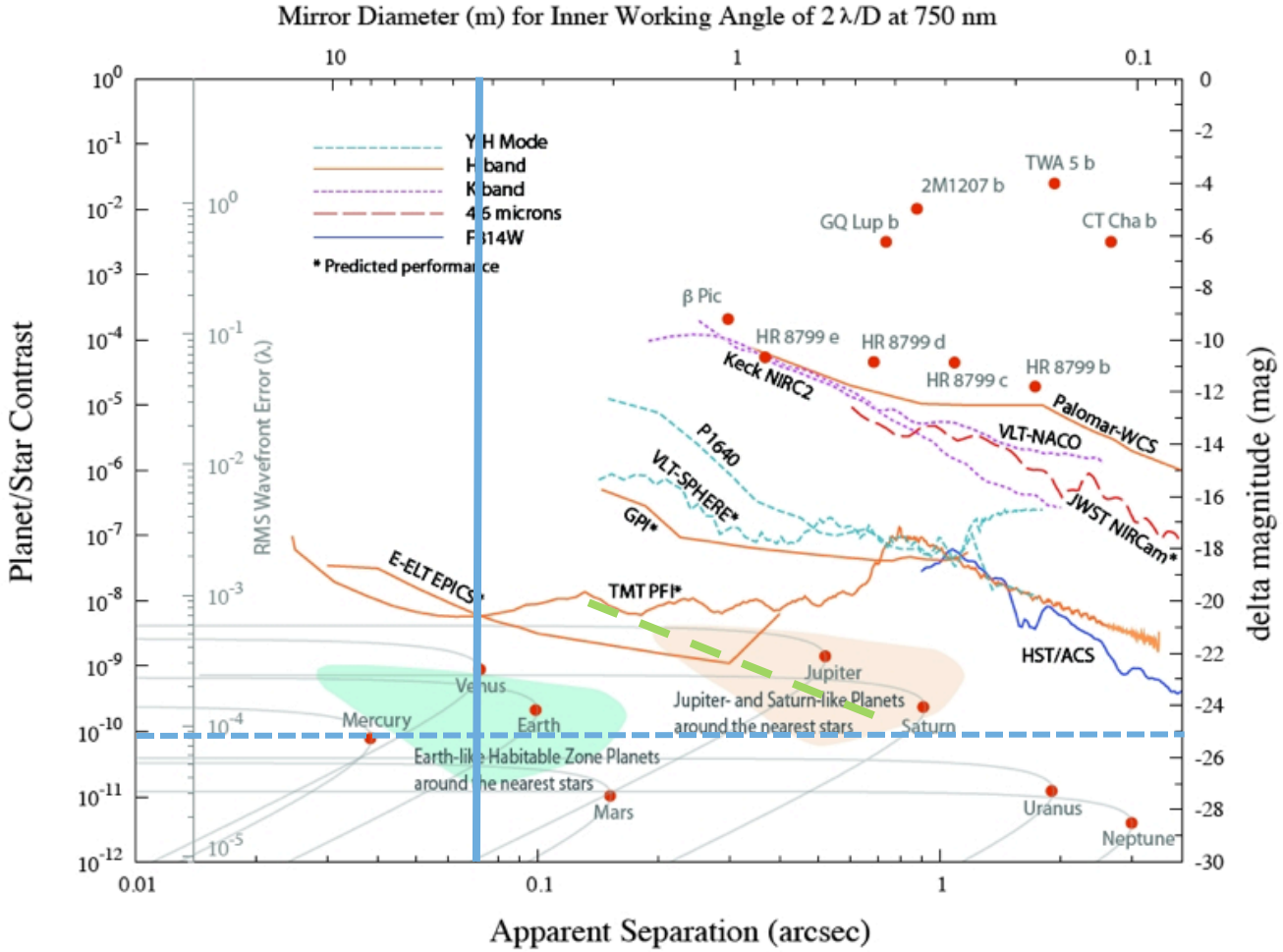
This diagram was taken from a presentation by Wes Traub at the Exopag in June 2015. Added in red is the IWA of a full-sized starshade for WFIRST.

Planned Spectroscopy Missions

The WFIRST internal coronagraph team is considering some spectroscopy, but it will be lucky to do super-Jupiters.

A WFIRST starshade provides serious spectroscopic capability.

Under some circumstances it will provide the first biomarkers.



This diagram was assembled by Peter Lawson for the Exoplanet Office. The dashed green line shows roughly the limit on spectroscopy with a WFIRST internal Coronagraph. The vertical blue line shows the IWA of the WFIRST starshade. The horizontal blue shows an estimate of the faintness limit based on problems with background.

The Problems

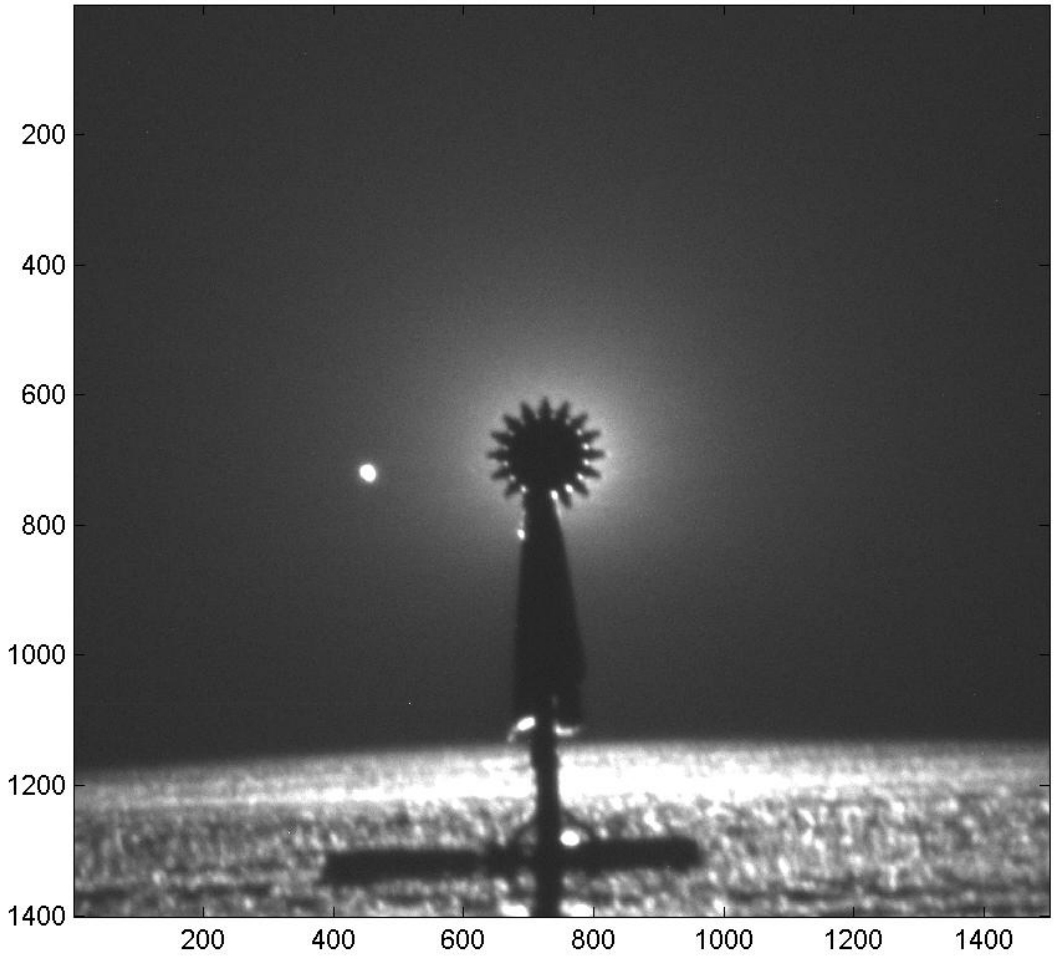
- IWA: The Earth at 10pc is never more than 0.1arcsec from its parent star, one HST resolution element. So we need large, state of the art telescopes, preferably in space.
- Contrast: The parent star is about 10^{10} times brighter than an Earth-like planet. Being so very close creates major problems with scatter, diffraction and background.
- Faintness: We need spectroscopy of ($\lambda/\delta\lambda$) 100 of m=30 stars. For comparison, the faintest star HST has even imaged is m=32.
- Exo-zodi: The Earth at 10pc has one-to-one signal to noise against 1Zodi of background (1Z=22nd magnitude per square arcsec) in a 4 meter diffraction limited telescope. This quadruples the amount of time required for a spectrum. We don't know anything about the level of exo-zodis to be encountered.

Starshades Work!

Desert testing (see example to right) has established that starshades robustly solve the contrast problem, and a sufficiently large starshade solves the IWA problem.

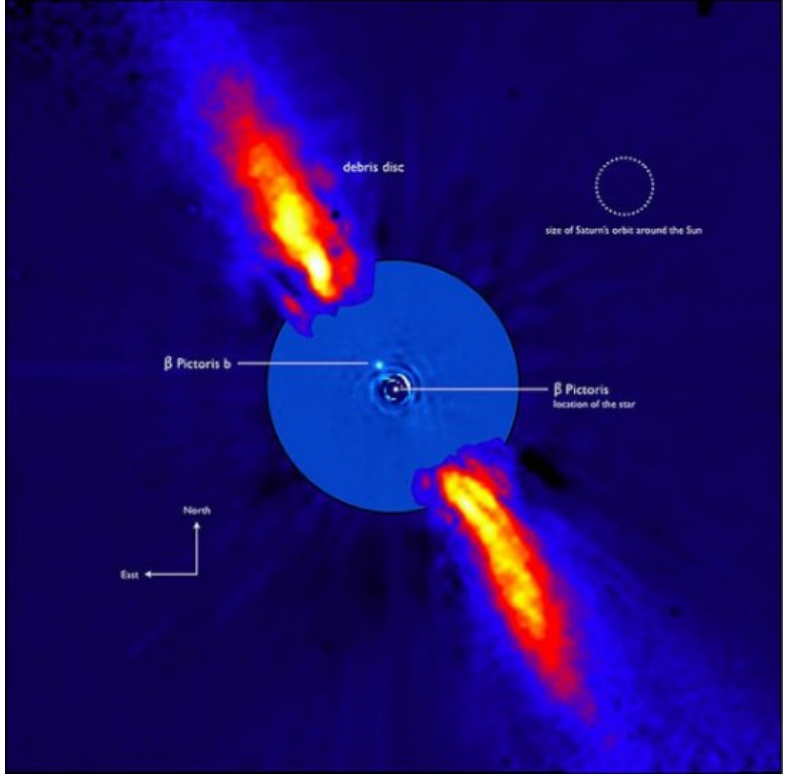
A sufficiently powerful (ie expensive) telescope in space can solve the faintness problem.

Remaining are tractable engineering problems like deployment and formation flying.



The Exozodi Problem

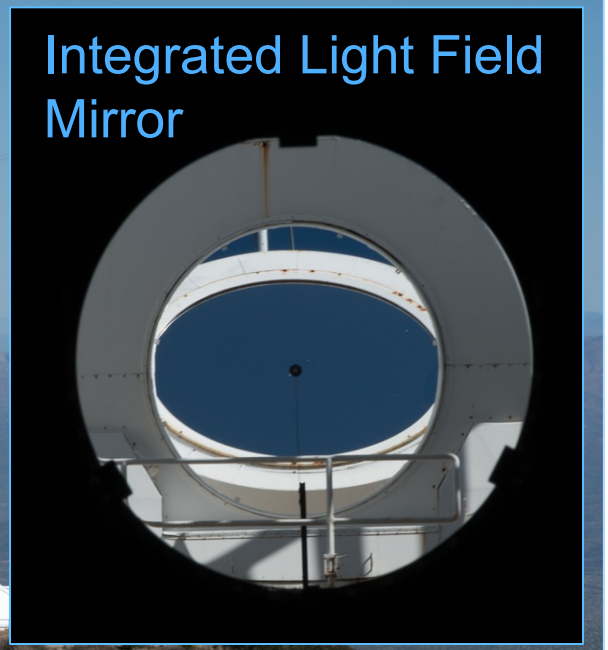
- Zodis as a unit can be confusing because they don't directly deal with solid angle distribution of the light.
- So it is best to use 1 Zodi = 22nd Magnitude per square arcsecond. Also assume that local sky brightness from zodiacal light is m=23/sq-as.
- A 2.4meter telescope, diffraction-limited at 500nm (eg WFIRST) has a resolution element 0.04" (40mas) in diameter, which is m=29/resol for 1Z of exozodi, and m=30/resol for local zodi. The Earth at 10pc is about m=30.
- That means we lose a factor of four in observing time against the local zodi alone, and a factor of ten with one zodi of exozodi added.
- Confusion from lumpiness means we cannot go much deeper.
- Ground based studies will gain information at the 10Zodi level at 5μ wavelength. This is ten times short of what we need to empower WFIRST. It is also at a wavelength that is ten times longer, and we do not know how to model the colors accurately across such a gap.
- Before serious money is spent we must have some idea of what fraction of star systems will have exozodi at 500nm below 1Z (or better yet down to 0.3Z).
- We cannot extrapolate with any confidence from an outer system to an inner system, so we will require something on the order of a dozen systems be measured in to at least the outer edge of the HZ.

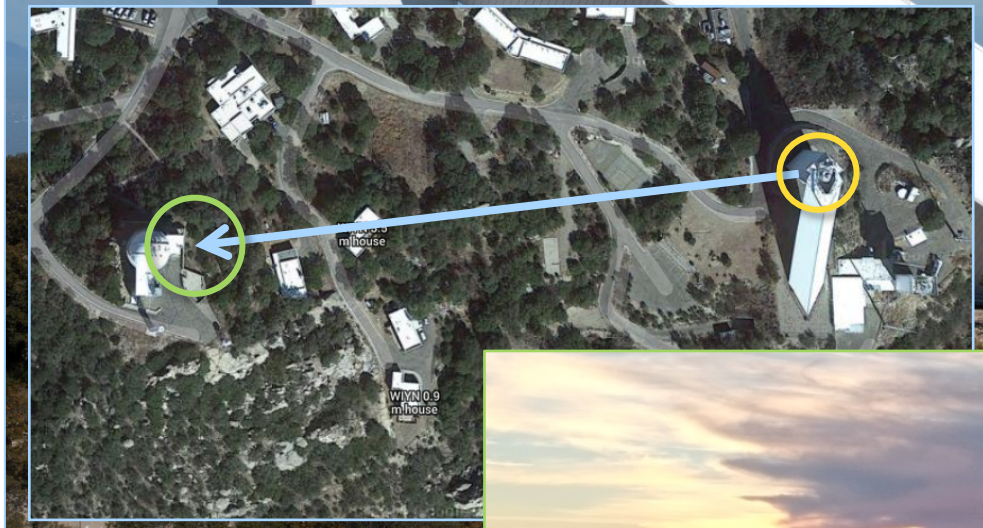


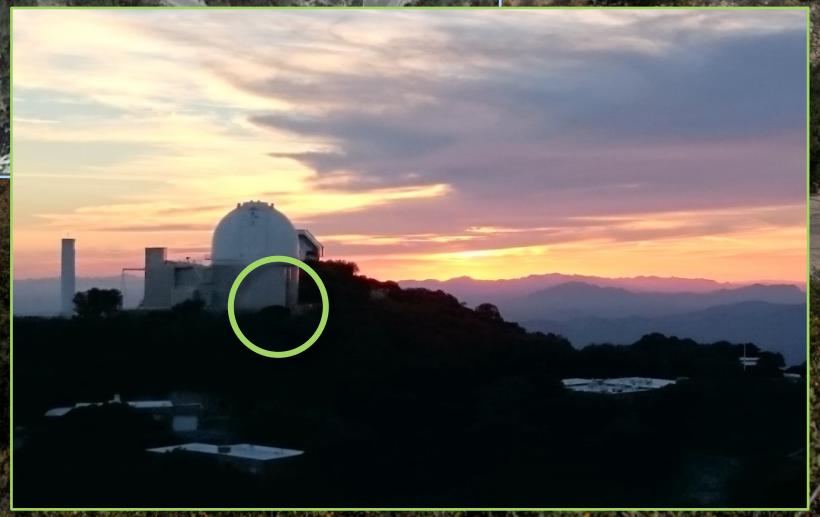
Exozodis are likely to be lump as can be seen in Beta Pic. To be seen above a lumpy background, a planet must have surface brightness comparable to the background itself. One simply cannot find it if it is 10% or less of the exozodi.

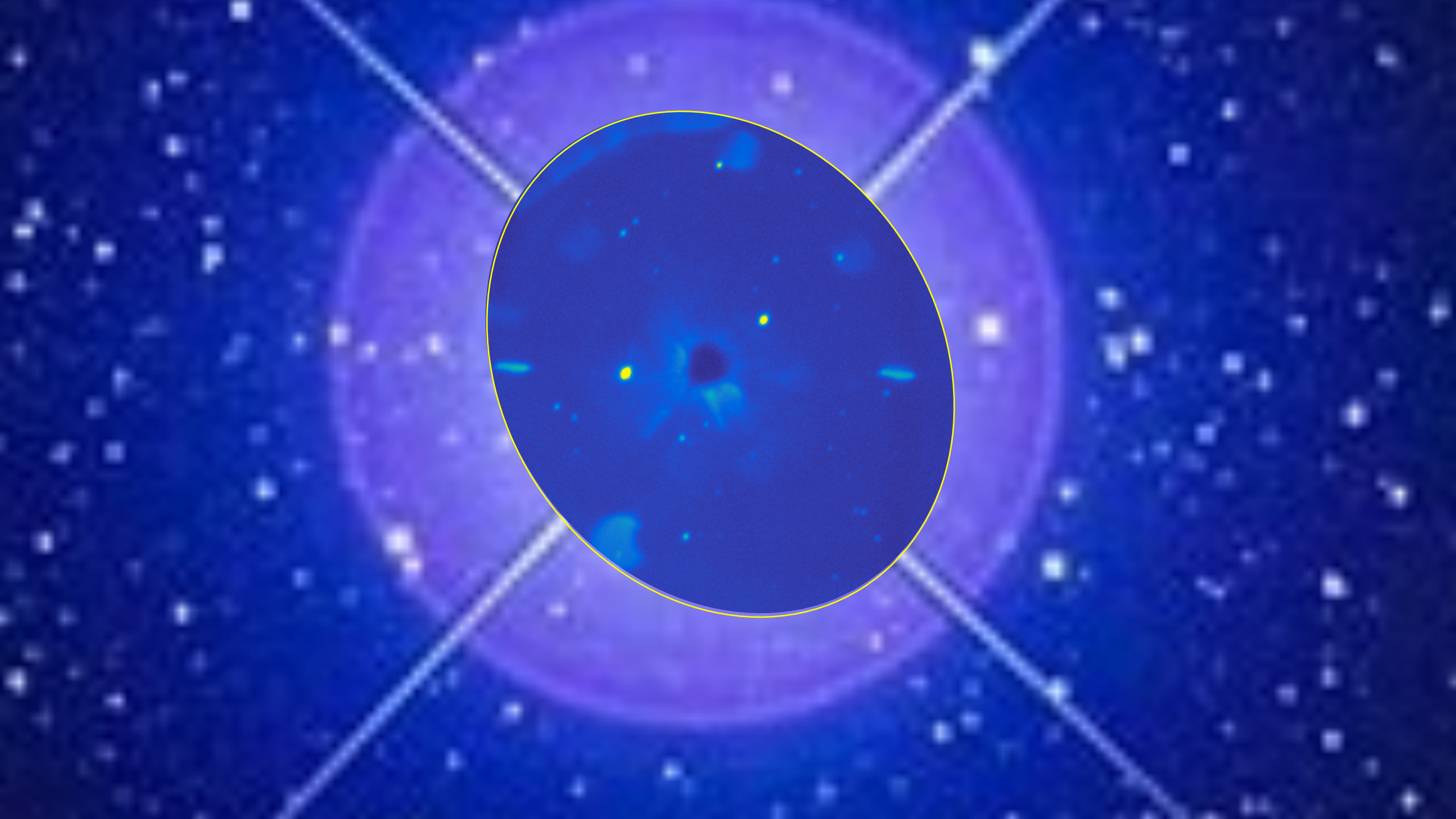
July Test

West Heliostat









The WFIRST Opportunity

"Rendezvous Mission"

- 80% of the cost of a starshade mission is in the large space telescope the Earth problem requires.
- WFIRST is the only planned mission capable of being adapted to a starshade.
- We should advocate for a separate starshade project, to be coordinated with WFIRST, but funded separately.
- We cannot wait for the 2020 decadal review to get started.
- We need to be at TRL5 by 2019.
- That can be done if we get full support for the remaining technology development needed. No more partial measures!

Plan to Get Us Ready

TRL5 in 2019, Launch in 2025

- The TDEM Plan has not gotten us where we need to be.
  - Insufficient funding, too diffused
  - We're already five years behind schedule.
- The Instrumental Expertise to Build A Starshade Mission resides in the Space Astronomy Community.
  - We need to clearly enunciate to NASA what needs to be done, when it needs to be done, and what resources will be needed when. Then ask Congress and NASA to support it.
  - That way the managers will have a well-defined plan to support
- Northrop, JPL and Colorado have started assembling a plan to get there.
- Please contact me if you are interested in joining this technology development and I have not yet contacted you.
- Plan Includes:
  - TRL development of components
    - e.g. deployment, formation flying etc
  - System Level Demo Suborbitally
    - Sidereostat Approach

All We Need to Do

- Stop Second-Guessing Ourselves
- Give unanimous support to the concept of a starshade rendezvous mission to be started asap.
- Get Organized on How to Proceed
- Let Congress and NASA do their jobs (with our vocal support)

- JUST DO IT

- Could be the most exciting space mission ever!
- We Might Find Life!