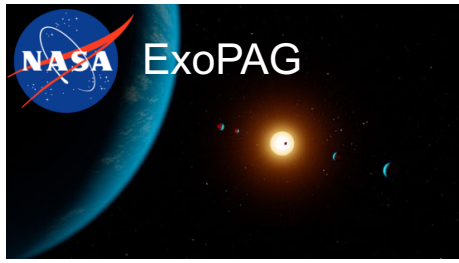
A SAG Proposal on ExoZodiacal Disks

John Debes, ExoPAG EC

STScI

It's been 10 years…



- First SAG: Debris Disks and ExoZodis

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The Exozodiacal Dust Problem for Direct Observations of Exo-Earths

AKI ROBERGE,[1] CHRISTINE H. CHEN,[2] RAFAEL MILLAN-GABET,[3] ALYCIA J. WEINBERGER,[4] PHILIP M. HINZ,[5] KARL R. STAPELFELDT,[1] OLIVIER ABSIL,[6] MARC J. KUCHNER,[1] AND GEOFFREY BRYDEN[7]

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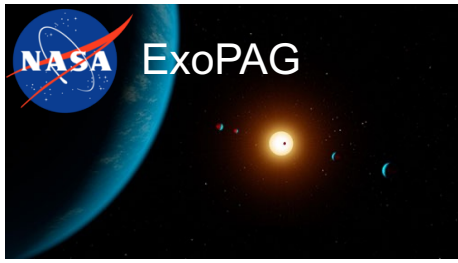
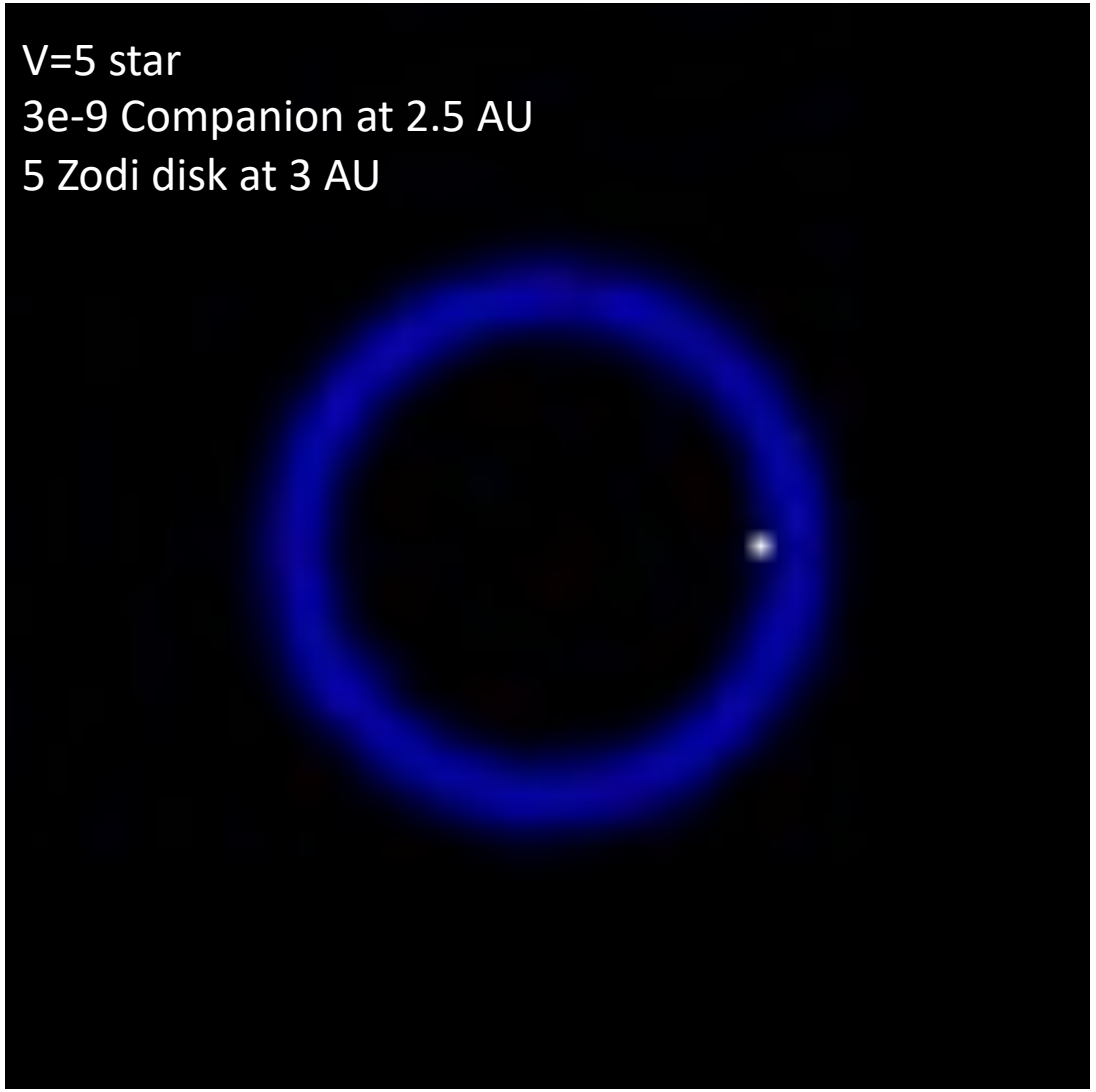
ABSTRACT. Debris dust in the habitable zones of stars—otherwise known as exozodiacal dust—comes from extrasolar asteroids and comets and is thus an expected part of a planetary system. Background flux from the solar system's zodiacal dust and the exozodiacal dust in the target system is likely to be the largest source of astrophysical noise in direct observations of terrestrial planets in the habitable zones of nearby stars. Furthermore, dust structures like clumps, thought to be produced by dynamical interactions with exoplanets, are a possible source of confusion. In this article, we qualitatively assess the primary impact of exozodiacal dust on high-contrast direct imaging at optical wavelengths, such as would be performed with a coronagraph. Then we present the sensitivity of previous, current, and near-term facilities to thermal emission from debris dust at all distances from nearby solar-type stars, as well as our current knowledge of dust levels from recent surveys. Finally, we address the other method of detecting debris dust, through high-contrast imaging in scattered light. This method is currently far less sensitive than thermal emission observations, but provides high spatial resolution for studying dust structures. This article represents the first report of NASA's Exoplanet Exploration Program Analysis Group (ExoPAG).

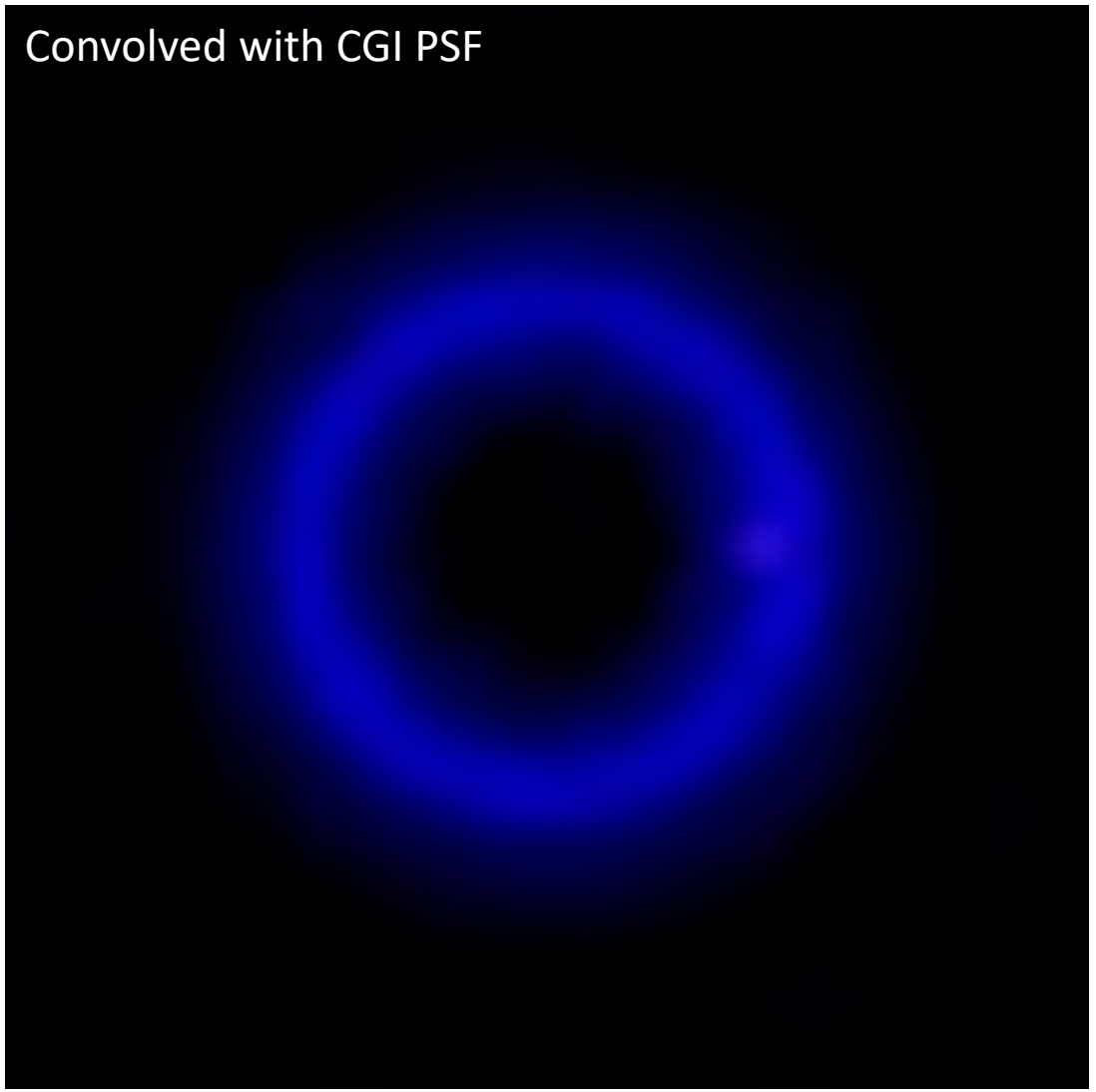
ExoZodis: Opportunity and Adversity



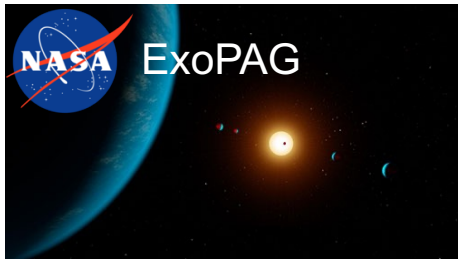
V=5 star
3e-9 Companion at 2.5 AU
5 Zodi disk at 3 AU

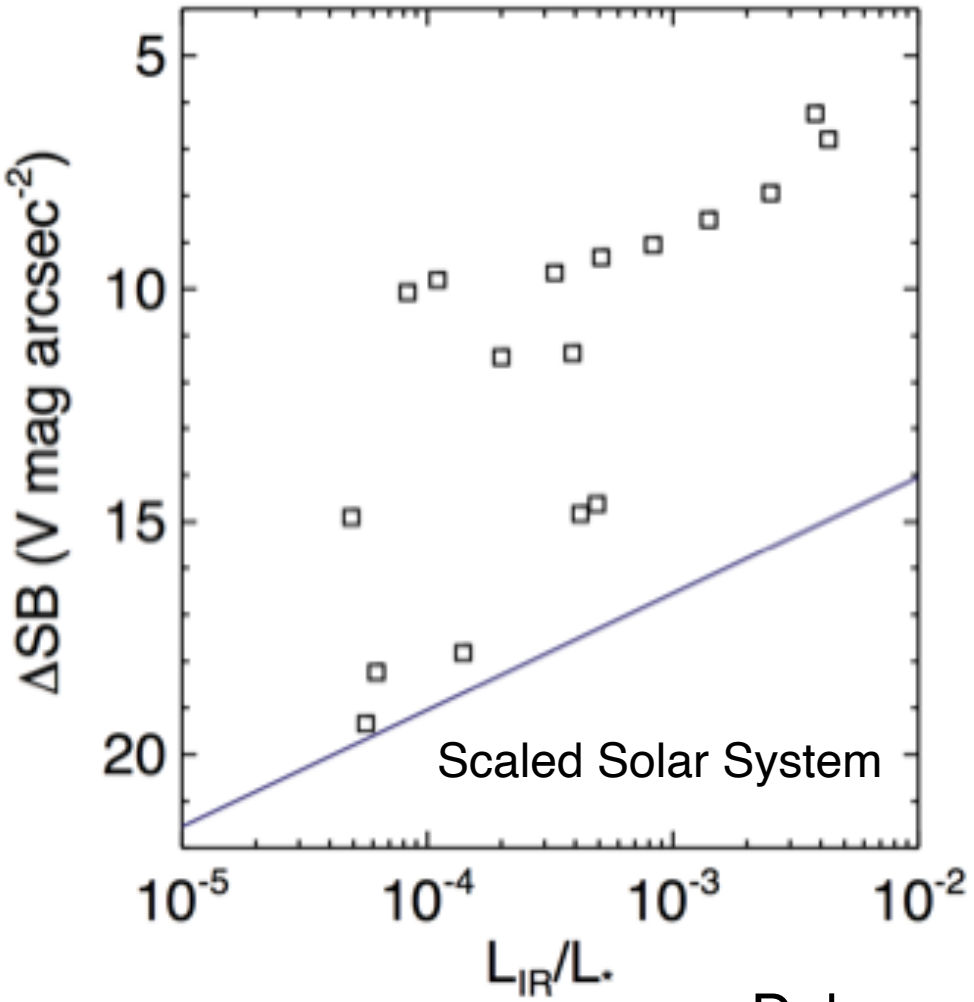


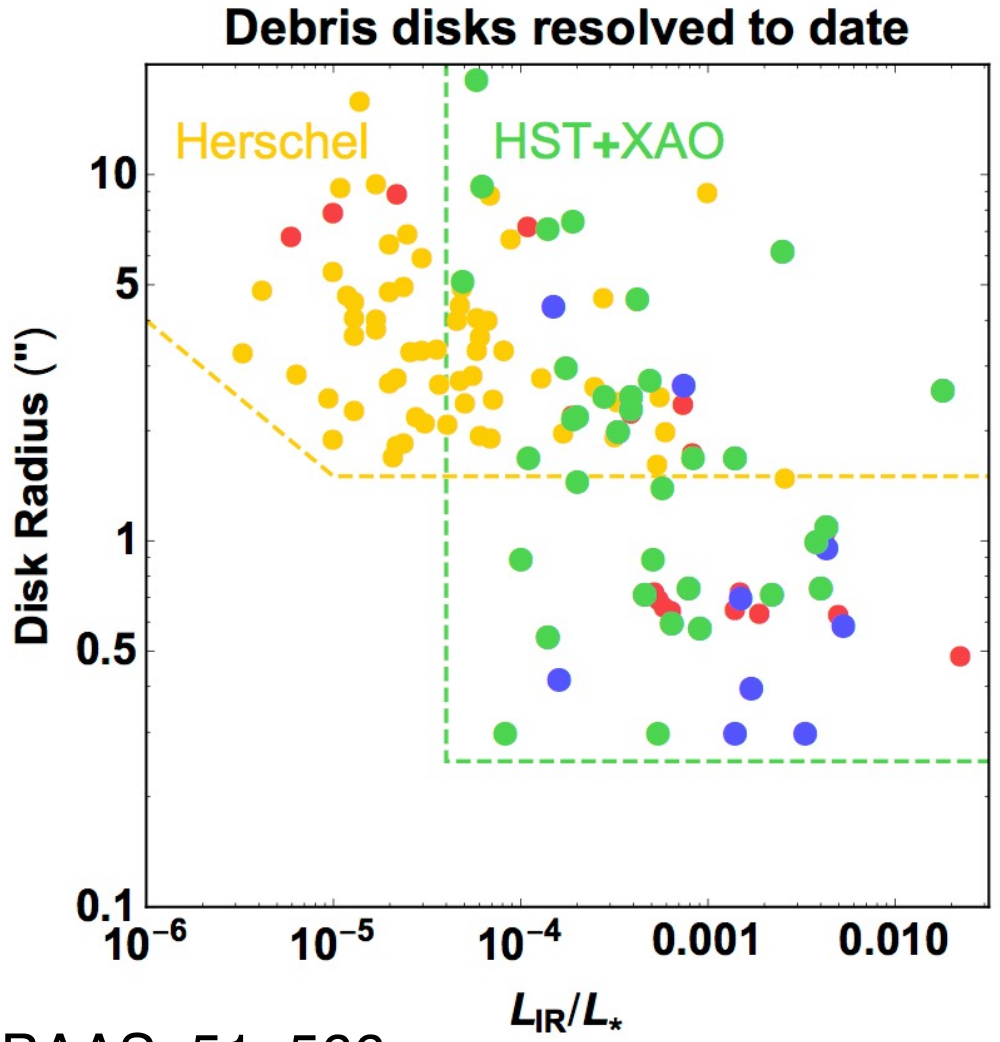
Convolved with CGI PSF



Cold Debris Disks

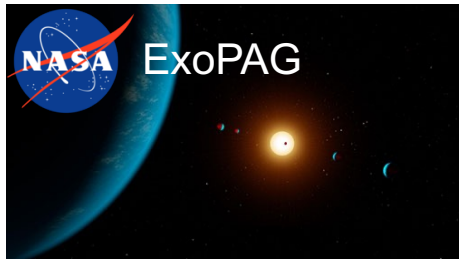




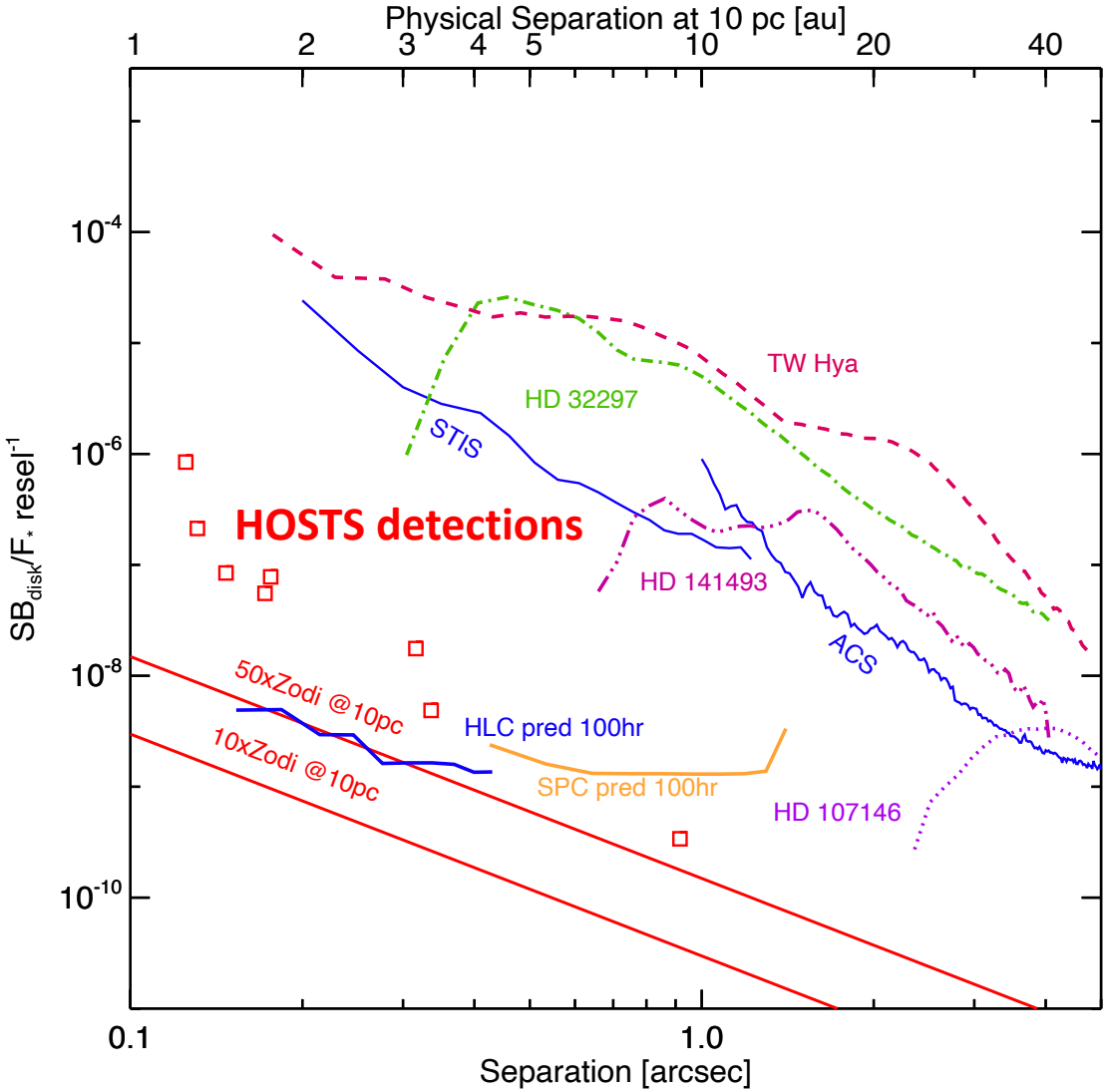


Debes et al. 2019, BAAS, 51, 566

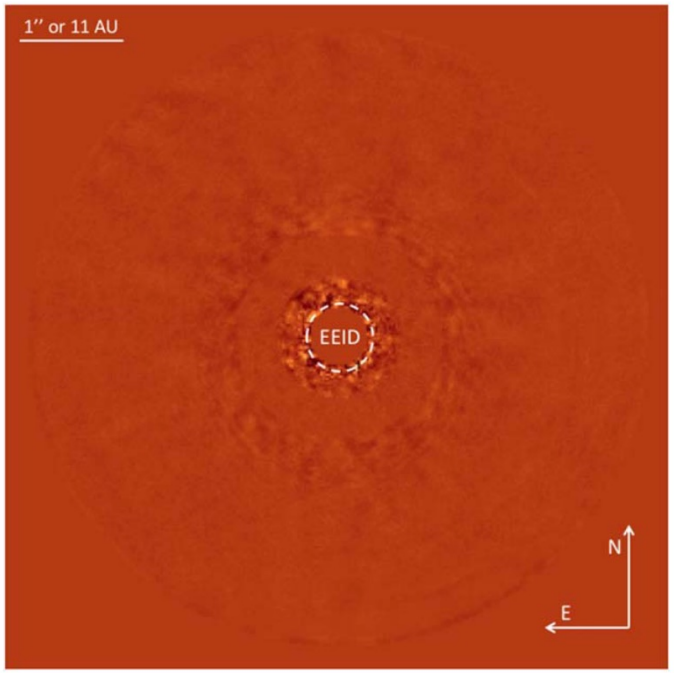
Surveying Nearby Stars



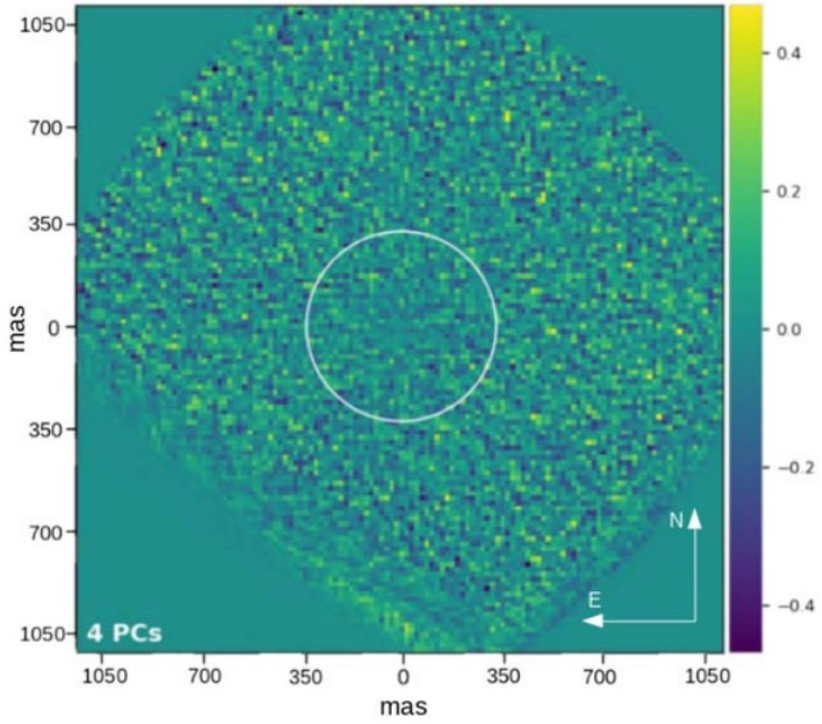
The next 10 years will see us probing the terrestrial planet forming region of nearby stars in an unprecedented way



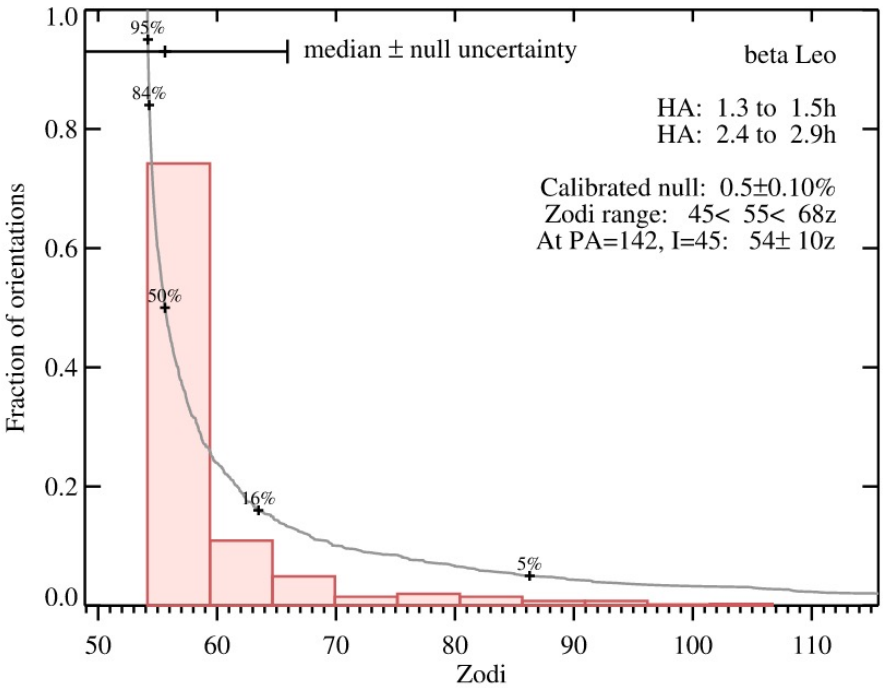
Research Vignette: Beta Leo



L' imaging for giant planets



N' imaging/interferometry for dust

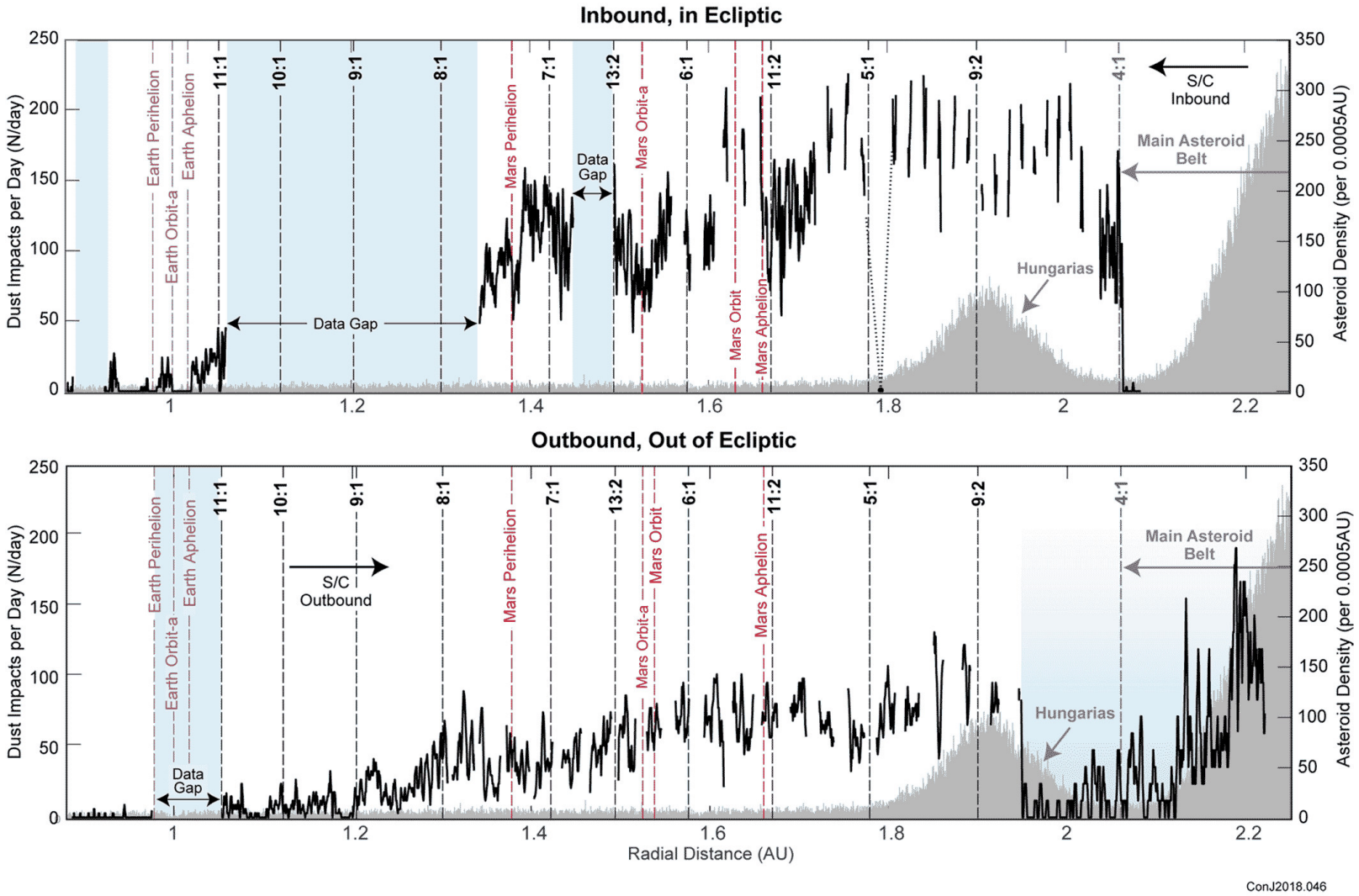


55+/-10 Zodis at ~0.3"

Also:
Planet searches around Alpha Cen in the mid-IR
Future JWST observations
ELT mid-IR imaging

Defrere et al., 2021

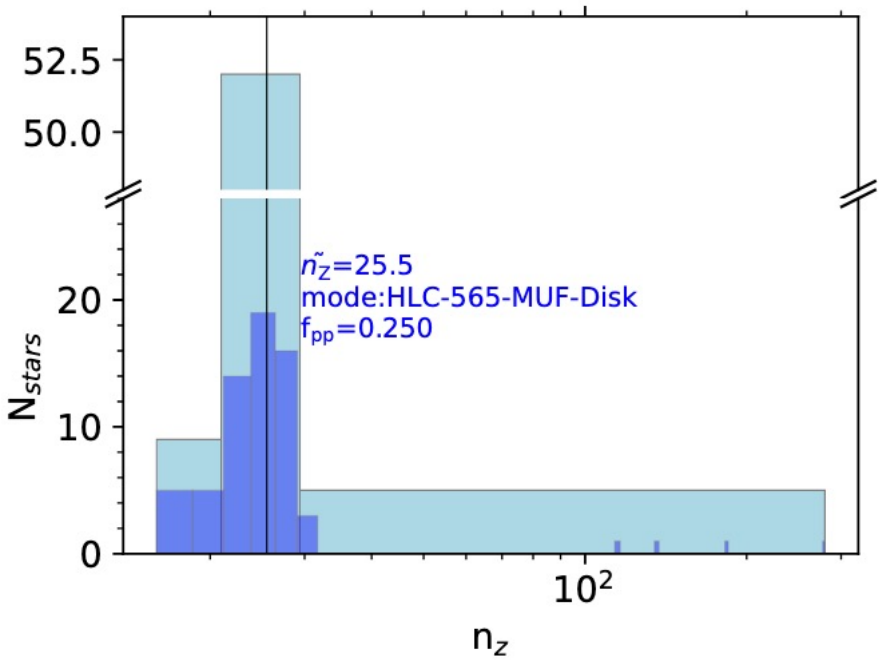
Research Vignette: Juno



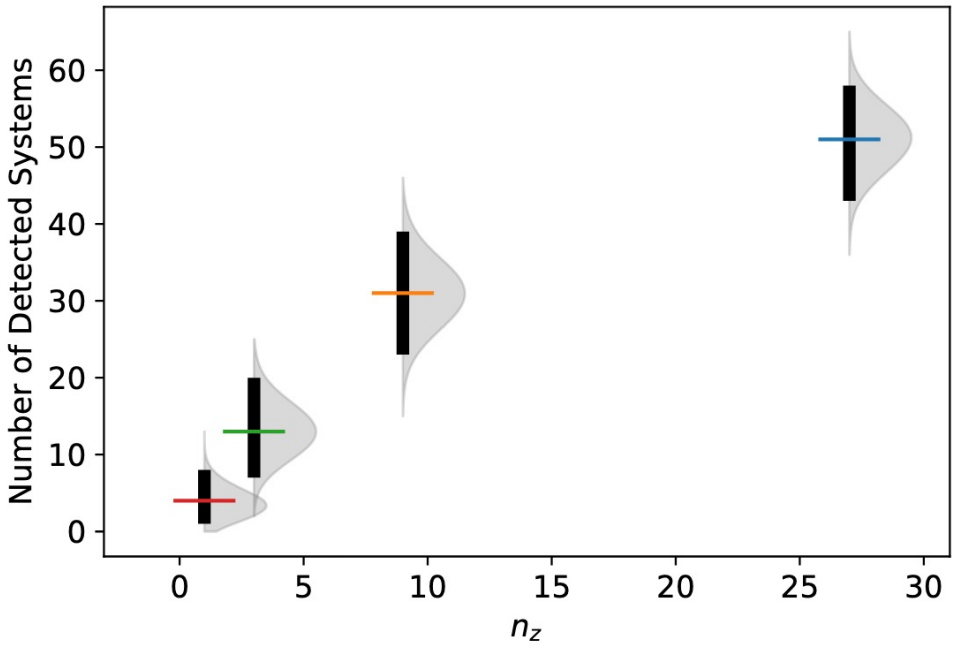
Also:
Parker Solar Probe
New Horizons
Others?

Jorgensen et al., 2020

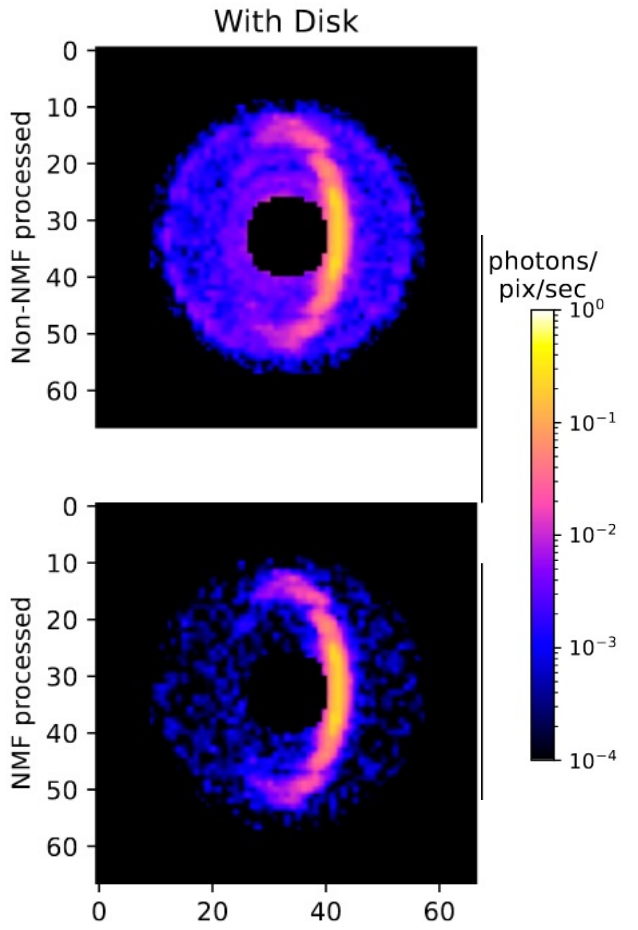
Research Vignette: Roman/CGI



SNR~5/resol detection limit
Current best estimates
Requires successful tech demo

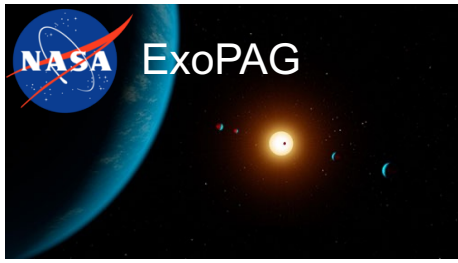


95% confidence intervals for number of detections of exozodis in HabEx target list as function of median zodi level



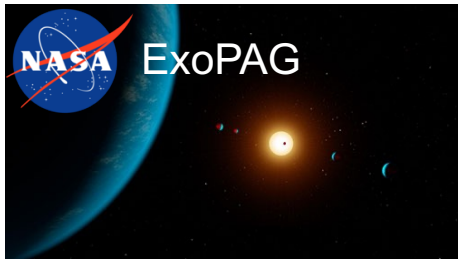
Douglas et al., 2021

A new SAG Proposal



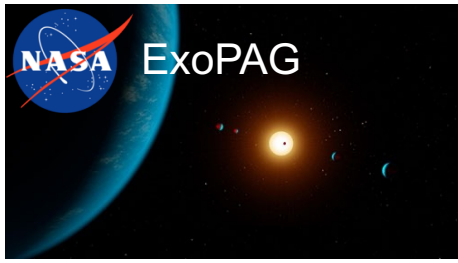
- Review the current state of knowledge for warm zodiacal dust in the Solar System and around nearby stars—is it scalable to all stellar masses?
  - i.e. studies of IDPs, dust scattering phase functions, polarimetry of dust
- Report on the current state of knowledge on the average exozodi level of nearby stars as determined by current measurements
  - Opportunities for existing observatories such as ALMA, HST, ground-based interferometers?
  - Reconciling hot dust seen in 2 micron interferometric surveys vs. mid-IR surveys
- Identify any gaps in knowledge for the Solar System Zodiacal Cloud that may be useful for understanding exozodi systems
- Identify any gaps in our physical knowledge of dust that, if addressed, could help predict scattered light from dust in visible wavelengths
  - Improved empirical, theoretical, or lab studies?

A New SAG Proposal



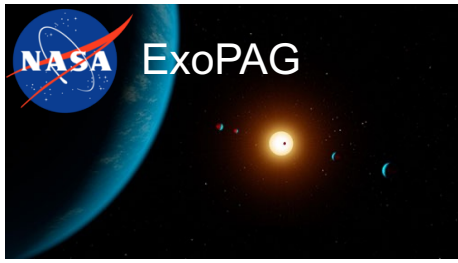
- Identify extended source detection and image post-processing methods that may be relevant for detecting exozodi disks with future missions or archival data
  - Optimize detection of disks
- Provide findings on whether an empirical method for predicting scattered light from thermal emission that is sufficiently robust to encompass the uncertainties of dust properties exists and determine the effects of such uncertainties on exoplanet imaging survey yields
- Identify high priority disk systems that could help to better understand exozodi systems
- Provide findings for future work to better retire risks to direct imaging exoplanet surveys, such as whether exo-zodi disks add more than photon noise in background limited observations.

Join me!



- If approved, will advertise for scientists to join in this endeavor
- All are welcome, including planetary scientists, dust enthusiasts, and debris disk researchers
- Hope to release a report/publication as warranted

Full draft text



https://stsci.box.com/v/ExoPAGSAGToR