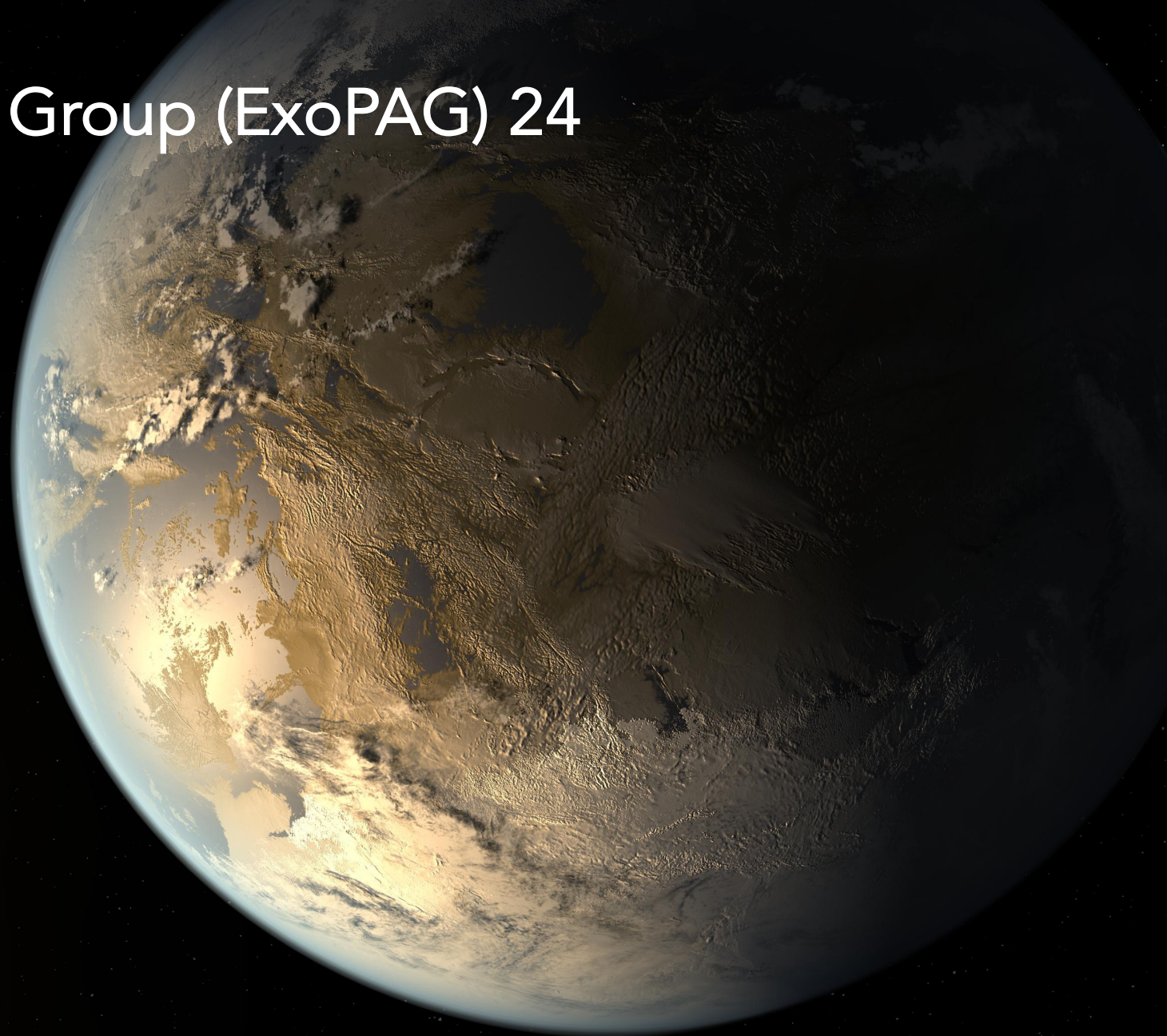


- 
- Welcome

# Exoplanet Program Analysis Group (ExoPAG) 24

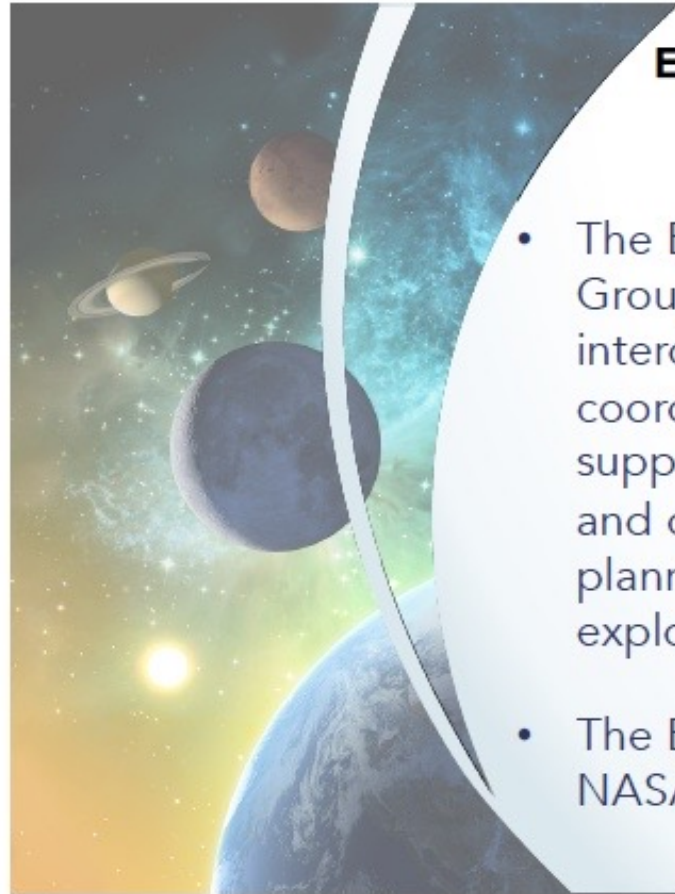
Michael Meyer (U. Michigan)  
Chair, ExoPAG Executive Committee

June 24, 2021





# Exoplanet Program Analysis Group: What is that anyway?



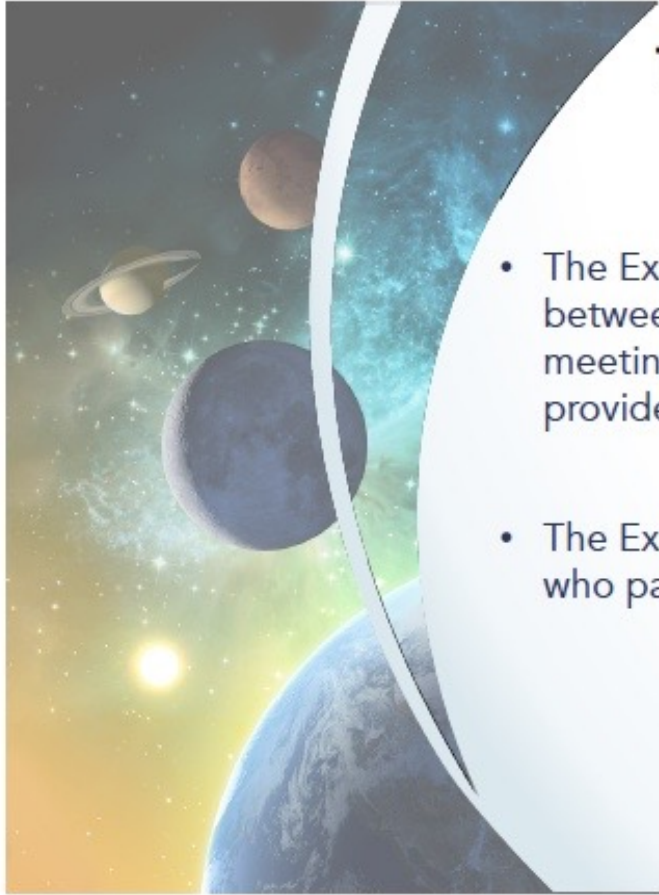
## Exoplanet Program Analysis Group (ExoPAG)

<https://exoplanets.nasa.gov/exep/exopag/overview>

- The Exoplanet Exploration Program Analysis Group (ExoPAG) is a community-based, interdisciplinary forum for soliciting and coordinating community analysis and input in support of Exoplanet Exploration objectives, and of their implications for architecture planning and activity prioritization for future exploration.
- The ExoPAG reports findings of analyses to the NASA Astrophysics Division Director.



# Exoplanet Program Analysis Group: What is that anyway?



## **The Exoplanet Program Analysis Group (ExoPAG)**

- The ExoPAG enables direct regular communication between NASA and the community through public meetings that give the community opportunities to provide scientific and programmatic input.
- The ExoPAG consists of all members of the community who participate in these open meetings.

# ExoPAG Executive Committee

Michael Meyer (Chair)

*Tom Barclay*

Natasha Batalha

Jacob Bean

*Jessie Christiansen*

Rebecca Jensen-Clem

John Debes

Tiffany Kataria

Josh Pepper

Dmitry Savransky

Laura Schaefer

*Vikki Meadows (Past Chair)*

Douglas Hudgins (Astrophysics)

Hannah Jang-Condell (ExEP DS)

Doris Daou (Planetary Liaison)

Richard Eckman (Earth Liaison)

Gaylan Fowler (Heliophysics Liaison)

University of Michigan

*University of Maryland*

NASA-Ames

The University of Chicago

*NExSci/Caltech*

UC-Santa Cruz

Space Telescope Science Institute

JPL/Caltech

Lehigh University

Cornell

Stanford University

*University of Washington*

NASA HQ

NASA HQ

NASA HQ

NASA HQ

NASA HQ

*Thank you for your service!*



# ExoPAG Executive Committee

|                                  |   |
|----------------------------------|---|
| Michael Meyer (Chair)            | University of Michigan                    |
| Natasha Batalha                  | NASA-Ames                                 |
| Jacob Bean                       | The University of Chicago                 |
| <i>Michael Bottom</i>            | <i>The University of Hawaii</i>           |
| <i>Ofer Cohen</i>                | <i>University of Massachusetts Lowell</i> |
| <i>Knicole Colon</i>             | <i>Goddard Space Flight Center</i>        |
| John Debes                       | Space Telescope Science Institute         |
| Tiffany Kataria                  | JPL/Caltech                               |
| <i>Ilaria Pascucci</i>           | <i>The University of Arizona</i>          |
| Josh Pepper                      | Lehigh University                         |
| Dmitry Savransky                 | Cornell                                   |
| Laura Schaefer                   | Stanford University                       |
| Douglas Hudgins (Astrophysics)   | NASA HQ                                   |
| Hannah Jang-Condell (ExEP DS)    | NASA HQ                                   |
| Doris Daou (Planetary Liaison)   | NASA HQ                                   |
| Richard Eckman (Earth Liaison)   | NASA HQ                                   |
| Gaylan Fowler (Heliophys Liason) | NASA HQ                                   |

*Our newest members!*

| ExEP Program (Chair: Michael Meyer)   |  | Speaker                                   | Time (EST) | Duration |
|---|--|---|------------|----------|
| Welcome   |  | Michael Meyer (U. Michigan)               | 12:00 PM   | 0:10     |
| NASA Headquarters Exoplanet Exploration Program Overview                      |  | Hannah Jang-Condell (NASA HQ)             | 12:10 PM   | 0:30     |
| Exoplanet Exploration Program Office Overview                                 |  | Gary Blackwood (NASA JPL)                 | 12:40 PM   | 0:15     |
| Program Science Update  |  | Eric Mamajek (NASA JPL)                   | 12:55 PM   | 0:15     |
| ExoExplorers Update   |  | Tiffany Kataria (NASA JPL)                | 1:10 PM    | 0:15     |
| Exoplanet Exploration Program Technology Update                               |  | Brendan Crill (NASA JPL)                  | 1:25 PM    | 0:15     |
| BREAK (15 min)  |  |   | 1:40 PM    | 0:15     |
| Science Updates (Chair: Knicole Colon)  |  |   |            |          |
| Heliophysics Overview   |  | Alex Glocer (GSFC) & Holly Gilbert (UCAR) | 1:55 PM    | 0:30     |
| SAG21 update- The Effect of Stellar Contamination on Space-based Transmission |  | Néstor Espinoza (STSCI)                   | 2:25 PM    | 0:20     |
| The Pandora SmallSat Mission: <i>Science Objectives</i>                       |  | Emily Gilbert (U. Chicago)                | 2:45 PM    | 0:15     |
| The Pandora SmallSat Mission: <i>Instrument Design</i>                        |  | Jordan Karburn (LLNL)                     | 3:00 PM    | 0:15     |
| Multiplicity of TESS Objects of Interest                                      |  | Steve Howell (NASA Ames)                  | 3:15 PM    | 0:20     |
| BREAK (15 min)  |  |   | 3:35 PM    | 0:15     |
| Business Meeting (Chair: M. Meyer)  |  |   |            |          |
| SAG 22 Update- Investigating an Exoplanet Target Star Archive                 |  | Joshua Pepper (Lehigh U.)                 | 3:50 PM    | 0:05     |
| SIG2 Update- Exoplanet Demographics   |  | Jessie Christiansen (Caltech)             | 3:55 PM    | 0:15     |
| Future Activities and Possible Future Findings                                |  | General Discussion                        | 4:10 PM    | 1:05     |
| Adjourn   |  |   | 5:15 PM    |          |

# ExoPAG Recent Activities (since ExoPAG23)

- Launch of Exoplanet Explorers (T. Kataria)!
- On-line poll conducted on finding (next slides).
- Present to PSAC in March and June (L. Schaefer).
- Presented to APAC March 15-17 (upcoming June 29-30).
- Participated in NExSS/P/AG roundtable in May.  
*(Stay tuned for news about Exoplanets in Our Backyard II in 2022).*
- New APD Cross PAG activities:
  - Cross PAG SAG on URM in APD Space Science (proposed).
  - Discuss Tech Gap synergies & NASA data policy.

PLANET HOP FROM  
TRAPPIST-1

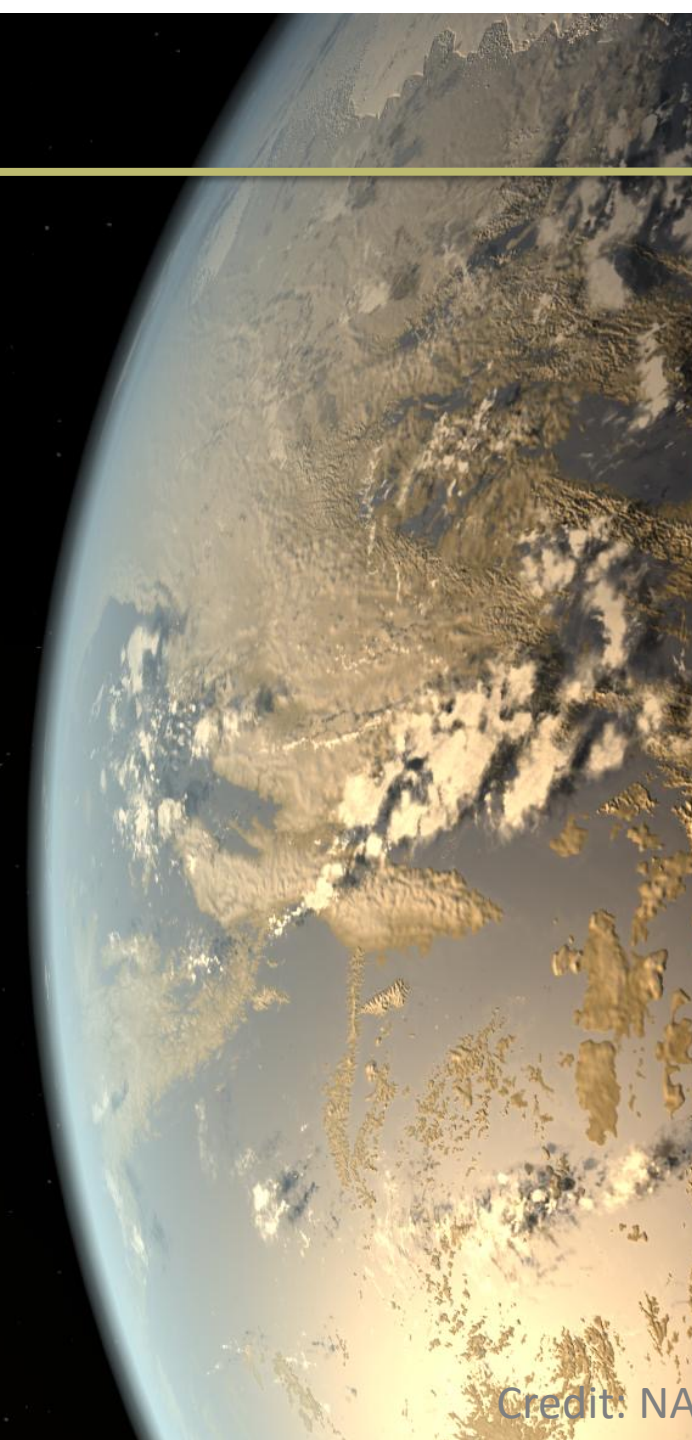
Credit: NASA

VOTED BEST "STUDY ABROAD" DESTINATION



# What are “ExoPAG Findings”?:

- Process for whole community to contribute to analyses forwarded to Astrophysics Division leadership as input.
- We do not give “recommendations” but “findings” based on analysis.
- Three findings approved in January 2020 and one in March 2021.  
<https://exoplanets.nasa.gov/exep/exopag/exopagFoundingDocuments/exopag-findings/>
- Ideas for new findings solicited from community (e.g. ExoPAG email and at Business Meetings) and discussed at community forum (e.g. Summer ExoPAG).
- Those with community support are reviewed by ExoPAG EC and top 1-3 findings put forward to ExoPAG for a vote (more than 2/3 support needed to “pass”).
- Ideas not adopted (or selected for vote) can be kept and re-discussed in future.
- Affirmation of findings generally scheduled for winter ExoPAG meeting



# ExoPAG Proposed Finding: On-line Poll March 1-10

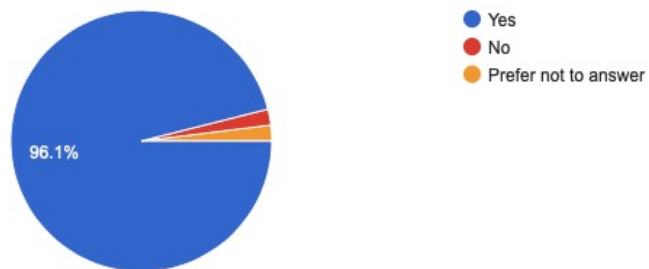
*On the value of investing in interdisciplinary exoplanet science of scale over longer periods of performance.*

<https://exoplanets.nasa.gov/exep/exopag/exopagFoundingDocuments/exopag-findings/>

- Meant to mimic process of in person votes (public, vote once).
- 50 participants vs. ~ 60 at face-to-face meeting.
- 41 yes, 7 no, 2 abstentions.
- Since more than 2:1 in favor, finding was shared with APD.

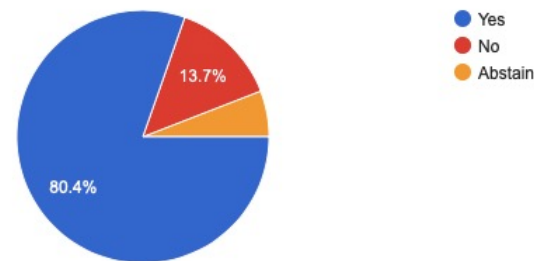
Have you participated in any previous ExoPAG Meetings?

51 responses



Do you support this finding?

51 responses





# Current Status of SAGs and SIGs

| Close Year | SAG or SIG | Title  | Lead                    |
|------------|------------|--|-------------------------|
| 2021       | SAG 19     | Exoplanet imaging signal detection theory and rigorous contrast metrics (final report accepted by APD and closed!) | Mawet & Jensen-Clem     |
| ----       | SIG 2      | Exoplanet Demographics (report this meeting)   | Christiansen & Meyer    |
| ----       | SIG 3      | Exoplanet Solar System Synergies (on-going).   | Meadows & Mandt         |
| ----       | SAG 21     | Stellar Contamination on Transit Spectra (report this meeting)   | Rackham & Espinoza      |
| ----       | SAG 22     | Exoplanet Host Properties (on-going)   | Pepper, Stark, & Hinkel |

# SAG 19 Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics

## Summary of Findings

- The contrast curve represents a single choice of a detection threshold, false positive fraction, and true positive fraction (e.g. a  $3\sigma$  contrast curve indicates a detection threshold of  $3\sigma$ , a false positive fraction of 0.001 assuming the noise follows a Gaussian distribution, and a true positive fraction of 0.5). Fixing these values with respect to separation from the central star may not be optimal for all applications.
- A contrast curve can be invoked as a frequentist upper limit on the detectability of a planet with a certain separation and brightness. However, a Bayesian upper limit is better suited to rejecting hypotheses regarding a particular planet's detection because it is a statement about the probability of a parameter (e. g. a planet's brightness) to lie within a given interval in the data.
- The contrast curve includes the implicit assumption that the noise in the science image follows a Gaussian distribution. However, the presence of speckles near the coronagraph's inner working angle in the final post-processed science image indicate that the noise is not fully whitened.
- Modern techniques for speckle subtraction (e. g. the Regime-Switching Model detection map; [Dahlqvist et al., 2020](#)), generally outperform first-generation techniques (e. g. LOCI; [Lafrenière et al., 2007](#)) when applied to the same datasets. However, machine learning techniques (e. g. SODINN; [Gomez Gonzalez et al., 2018](#)), do not yet outperform first-generation techniques.



# ExoPAG 24 Final Session: Today 4:10-5:15 EST.

---

- Brief update on SIG3.
- Review of progress on actions.
- Share new ideas for ExoPAG priorities and activities!
- Consider proposing a finding for future discussion!
- Feel free to share announcements for the community.

*Note: We anticipate ExoPAG Community Forum to be held after Astro2020 is released.*

- Meeting Website & Agenda: [bit.ly/ExoPAG24](https://bit.ly/ExoPAG24)
- ExoPAG FAQ Document: [bit.ly/ExoPAG24\\_FAQ](https://bit.ly/ExoPAG24_FAQ)
- ARC Q&A Tool: [bit.ly/ExoPAG24\\_ARC](https://bit.ly/ExoPAG24_ARC)
- Suggestions Form: [bit.ly/ExoPAG24\\_Suggestions](https://bit.ly/ExoPAG24_Suggestions)
- Proposed Findings Form: [bit.ly/ExoPAG24\\_Findings](https://bit.ly/ExoPAG24_Findings)



- 
- Back-up Slides

# ExoPAG Proposed Finding:

---

**On the value of investing in interdisciplinary exoplanet science of scale over longer periods of performance.**

"Whereas exoplanet science is inherently interdisciplinary, requiring expertise in heliophysics, earth science, planetary science, and astrophysics, among other disciplines, as well as deep and broad knowledge in theory, computation, observation, experiment, statistics, and instrument development, and whereas interdisciplinary research can require longer timeframes and greater resources to take full advantage of such diverse expertise within a collaboration, and whereas existing opportunities of scale that permit longer periods of performance to support interdisciplinary research teams are restricted to areas that specifically address the goals of the astrobiology program,

We find that longer term programs of scale (e.g. five year periods of performance and up to several million USD awards) would enable NASA to rapidly and efficiently address linked sets of the Exoplanet Exploration Program Science Gaps, for example 01-03, 02, 04-06, and 07-08-10, which contribute significantly to achieving NASA's strategic goals, provided that such new opportunities did not come at the expense of existing programs which are also extremely valuable to help NASA achieve its strategic goals."



- 
- Business Meeting Slides

# ExoPAG 24 Final Session: Today 4:10-5:15 EST.

---

- Brief update on SIG3 (Laura).
- Review of progress on actions (Eric/Karl).
- Share new ideas for ExoPAG priorities and activities!
- Consider proposing a finding for future discussion!
- Feel free to share announcements for the community.

*Note: We anticipate ExoPAG Community Forum to be held after Astro2020 is released.*



- Meeting Website & Agenda: [bit.ly/ExoPAG24](https://bit.ly/ExoPAG24)
- ExoPAG FAQ Document: [bit.ly/ExoPAG24\\_FAQ](https://bit.ly/ExoPAG24_FAQ)
- ARC Q&A Tool: [bit.ly/ExoPAG24\\_ARC](https://bit.ly/ExoPAG24_ARC)
- Suggestions Form: [bit.ly/ExoPAG24\\_Suggestions](https://bit.ly/ExoPAG24_Suggestions)
- Proposed Findings Form: [bit.ly/ExoPAG24\\_Findings](https://bit.ly/ExoPAG24_Findings)

# New Ideas for ExoPAG Activities:

- Consider a new exozodi SAG based on the results from the HOSTS survey, new results from ALMA, recent high contrast imaging of debris disks in reflected light, studies of dust in the Solar system (and beyond), and archival results from Spitzer/Herschel (cf. SAG-1 report). Do we need a renewed effort to assess risk to exoplanet imaging missions presented by zodiacal light? (J. Debes).
- Discussion of common standards for publishing exoplanet discoveries (D. Savransky).
- Analysis of synergies between ground- and space-based technology (wavefront control and diffraction suppression), as well as science algorithm development, in the context of high contrast imaging. This could be particularly relevant in the era of JWST, rapid developments on the ground (e.g. focal plane wavefront sensing), ELTs, Roman CGI, and future direct imaging missions (to be discussed in future).



# ExoPAG 24 Final Session: Today 4:10-5:15 EST.

---

- Brief update on SIG3 (Laura).
- Review of progress on actions (Eric/Karl).
- Share new ideas for ExoPAG priorities and activities!
- Consider proposing a finding for future discussion!
- Feel free to share announcements for the community.

*Note: We anticipate ExoPAG Community Forum to be held after Astro2020 is released.*

# Tentative Plans for ExoPAG Community Forum:

---

- After Astro2020 is released.
- Discussion to understand the recommendations, not proposing changes!
- May invite members of the committee for discussion:

<https://tinyurl.com/2skx23s5>

- NASA will be charged with making a formal response and will do so later in the year (and will not soliciting input on that at this community forum).
- Will also have other agenda items at this forum (e.g. update on SAG22, etc).



# ExoPAG 24 Final Session: Today 4:10-5:15 EST.

---

- Brief update on SIG3 (Laura).
- Review of progress on actions (Eric/Karl).
- Share new ideas for ExoPAG priorities and activities!
- Consider proposing a finding for future discussion!
- Feel free to share announcements for the community.

*Note: We anticipate ExoPAG Community Forum to be held after Astro2020 is released.*