



Jet Propulsion Laboratory
California Institute of Technology

Exoplanet Exploration Program Overview

Dr. Christine C. Moran, Deputy Program Manager

Jet Propulsion Laboratory

California Institute of Technology

June 11, 2022

ExoPAG 26, Hybrid

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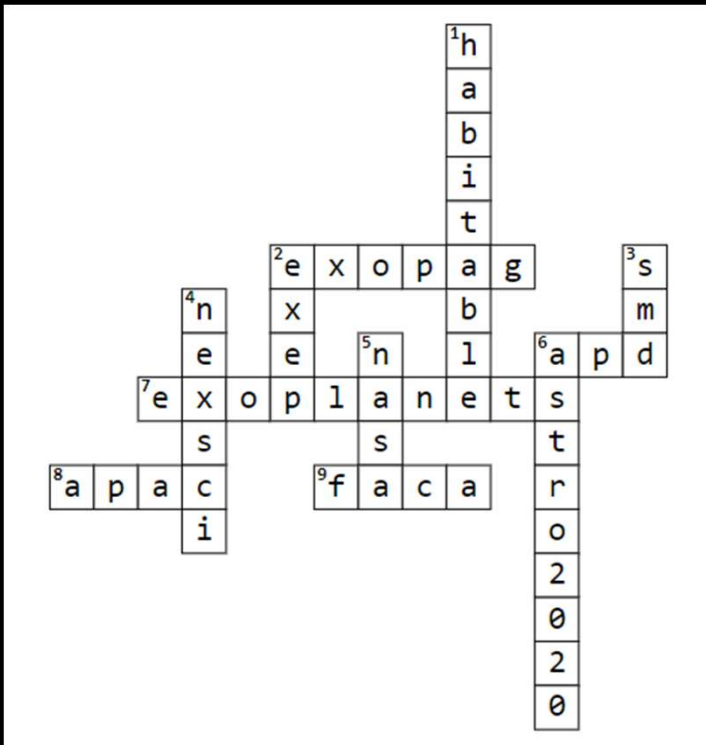
ExoPAG Terms of Reference

Exoplanet Program Analysis Group
Chartered by the Astrophysics Division



1. Articulate and prioritize the **key scientific drivers** for Exoplanet Exploration research ;
2. Evaluate the **expected capabilities of potential ExEP missions** for achieving the science goals of the Program ;
3. Evaluate ExEP goals, objectives , **investigations and required measurements** on the basis of the widest possible community outreach;
4. Articulate and prioritize focus areas for **needed mission technologies** ; and
5. Provide findings on related activities such as **ground-based observing, theory and modeling programs, laboratory astrophysics, suborbital investigations, data archiving and community engagement.**

Acronym Glossary



NASA HQ - NASA Headquarters, Washington DC

SMD - Science Mission Directorate

APD - Astrophysics Division, a division within SMD



Paul Hertz, Division Director
Sandra Cauffman, Deputy Director

APAC - Astrophysics Advisory Committee
- a FACA committee to APD

ExoPAG - Exoplanet Program Analysis Group

ExEP - Exoplanet Exploration Program, within APD
- At NASA HQs & JPL in Pasadena CA



E. Lucien Cox, Program Executive
Douglas Hudgins, Program Scientist

Hannah Jang-Condell, Dpy PS
Joshua Pepper, Dpy PS

NExSci - NASA Exoplanet Science Institute
- at Caltech in Pasadena CA

NASA Exoplanet Exploration Program

Astrophysics Division, NASA Science Mission Directorate

NASA's search for habitable planets and life beyond our solar system

Program purpose per Charter From the Astrophysics Division

1. Discover planets around other stars
2. Characterize their properties
3. Identify candidates that could harbor life



ExEP serves the Science Community and NASA:

- As a Focal point for exoplanet science and technology
- By Integration of cohesive strategies for future discoveries

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

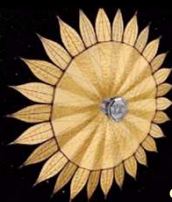
NASA Exoplanet Exploration Program

Mission Concepts

IR / O / UV Mission
Concepts

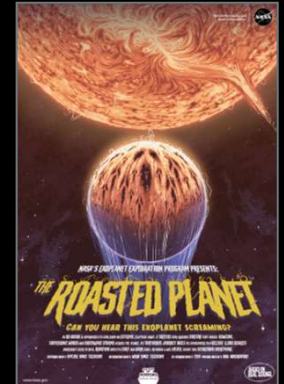
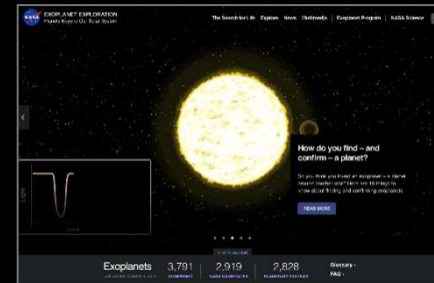


Coronagraph



Starshade

Exoplanet Communications

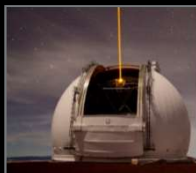


Supporting Research & Technology

Key Sustaining Research



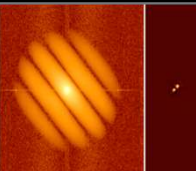
NN-EXPLORE



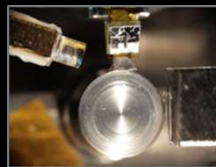
Keck Observatory



Large Binocular
Telescope
Interferometer



High Resolution
Imaging



Extreme Precision
Radial Velocity
Technology
Development



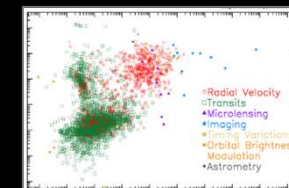
Coronagraph
Technology
Development



Starshade
Technology
Development (S5)

Technology Development

NASA Exoplanet Science Institute (NExSci)



Archives, Tools, Sagan Program,
Professional Engagement

NASA Exoplanet Exploration Program

Astrophysics Division, Science Mission Directorate



Changes since last
ExoPAG



Program Office (JPL)

PM - Dr. G. Blackwood
DPM - Dr. C. Moran
Chief Scientist - Dr. K. Stapelfeldt
Chief Technologist - Dr. N. Siegler

Exoplanet Exploration Program (NASA HQ)

Program Executive - E. L. Cox
Program Scientist - Dr. D. Hudgins
Deputy Program Scientists -
Dr. H. Jang-Condell
Dr. Joshua Pepper

Program Analysis Group (ExoPAG)

Dr. I. Pascucci, EC chair

Program Science Office

PCS - Dr. K. Stapelfeldt
DPCS - Dr. E. Mamajek
Scientist - Dr. T. Kataria
Science Ambassador -
Dr. A. Tripathi

Program Engineering Office

Chief Engineer - K. Warfield
Optical Engineer - Dr. R. Morgan
System Engineer - Dr. D. Ardila

Technical Assessment Committee (ExoTAC)

Dr. A. Boss, chair

Program Business Office

Manager - R. Lemus
Admin. - J. Gregory

Mission Assurance

Manager - P. Lock

Business Operations

Program Bus. Mgr. - M. Romejko
Resources - K. Marrero
Schedules - A. Strand

Program Development Management

Manager - Vacant
High Resolution Imaging Project

Exoplanet Communications (JPL)

Manager - A. Biferno
Writer/Editor - P. Brennan
Web Producer & Social Media
- K. Walbolt
Outreach Specialist - T. Khan

NN EXPLORE Project

PM - Dr. D. Ardila, JPL
PI - Dr. S. Mahadevan, PSU
Project Scientist -
Dr. B.J. Fulton, CIT
JPL EPRV Scientist -
Dr. J. Burt

Program Technology (JPL)

Manager - Dr. N. Siegler
Deputy - Dr. B. Crill
Dpy Manager - Dr. P. Chen
Program Post Doc- Dr. A. Potier

LBTI Project

PM - Dr. P. Willems, JPL
PI - Dr. P. Hinz, UCSC/UA
PS - Dr. C. Gelino, CIT

AstroComm (JPL)

Manager - A. Biferno
Outreach Specialist -
K. Soares

High Resolution Imaging Project (ARC)

PI - Dr. S. Howell
ExoFOP - Dr. D. Ciardi, CIT

NExScI

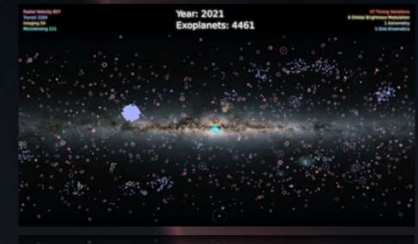
Ex Dir - Dr. C. Beichman, JPL/CIT
Dep Dir - Dr. D. Gelino, CIT
Chief Scientist - Dr. D. Ciardi, CIT
NExScI Mgr - Dr. S. Carey, CIT

Starshade Technology Project (JPL)

PM - Dr. P. Willems
PS - Dr. R. Hu

ExoComm – Outreach Highlights

- The [@NASAAxoplanets](#) Twitter account passed 1 MILLION followers!
- ExoComm released the Space telescope “superhero” video, with accompanying story: go.nasa.gov/3I1liVQ
- [Yasuhiro Hasegawa released a set of slides designed to help teachers](#)
- Popular social media included on Twitter with content using the Oscars as a jumping off point for an “exoplanet red carpet” featuring some of our favorite planets.
- On Mar 21 NASA’s Exoplanet Archive confirmed 65 new planets, pushing the total past 5,000. ExoComm developed and released a [media release](#), [sonification video](#), and an [overview video](#). The videos have a combined view total of over 2 million.



NASA Response to Astro2020

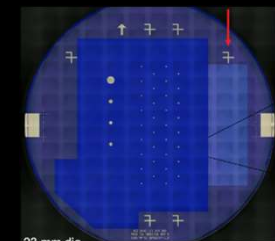
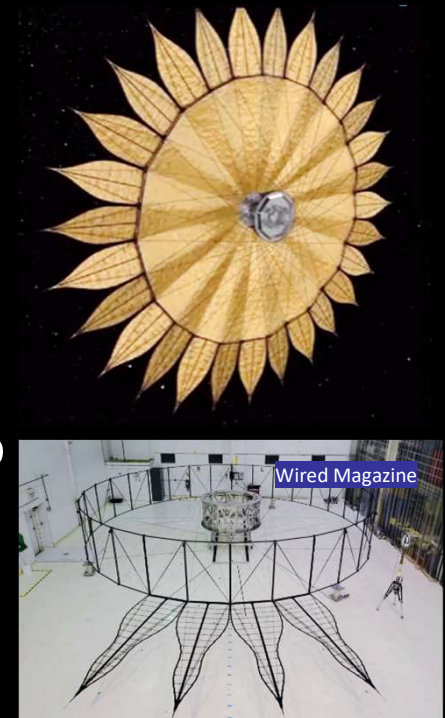
- Astro2020 recommended a *Great Observatory Mission and Technology Maturation Program* leading to an *Independent Review* prior to a new mission start
- The Astrophysics Division is responding with the Great Observatories Maturation Program (GOMaP) and the Exoplanet Exploration Program is actively supporting
- To learn more please attend:
 - Presentations in this ExoPAG by Brandt, Blackwood, Morgan, and Siegler on Sunday morning
 - Paul Hertz' *update to a joint PAG session 3-5pm June 12.*



Starshade Programmatic Updates

S5 = Starshade to Technology Readiness Level 5

- Both data challenge teams delivered results, papers in preparation
- NASA will discontinue future directed S5 funding
 - ExEP will transition from a directed funding to a competed model
 - Starshade technology proposals are expected to be in future ROSES solicitation
- Technology development continues in FY23 within remaining funding to complete planned milestones
- Starshade technology development will contribute to Decadal flagship trades studies
 - [Wired magazine](#) featured an article in January on the relative merits of starshades and coronagraphs for exoplanet imaging, including interviews with many in the exoplanet community



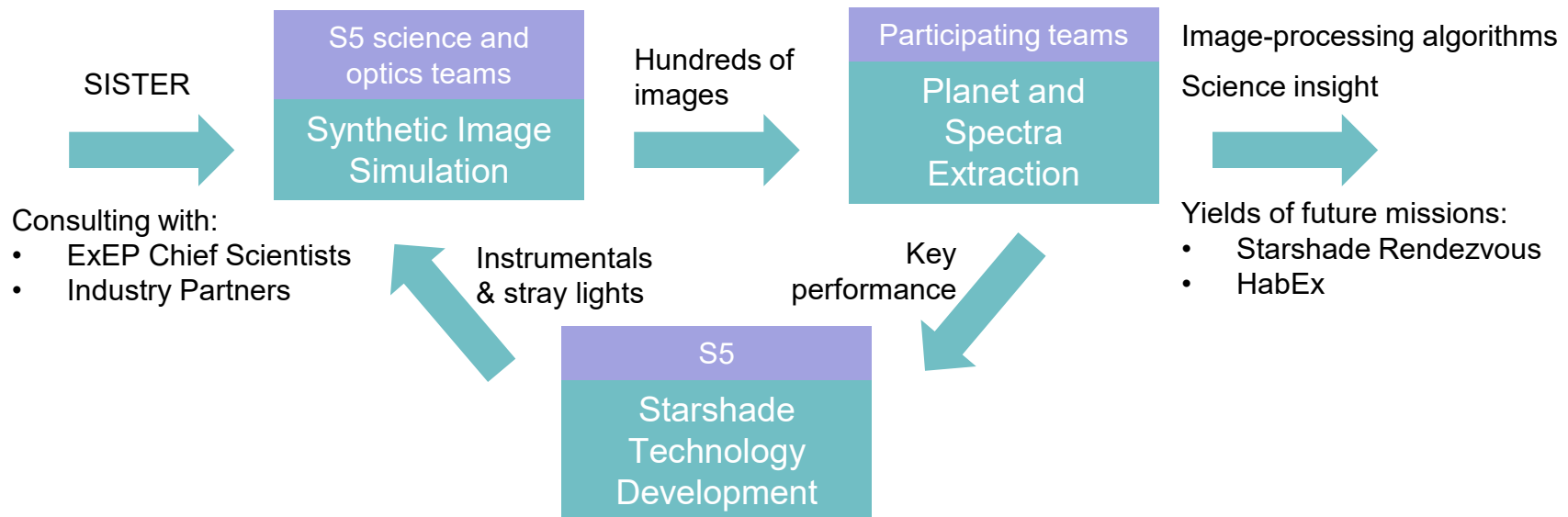
S5 Petal Launch and Unfurl subsystem

Starshade Exoplanet Data Challenge



ExoPlanet Exploration Program

- Objectives:
 - Validate requirements from science to key performance parameters
 - Quantify the accuracy of calibration of solar glint and exozodiacal light
 - Prepare science community for analyzing starshade exoplanet observations
- A total of 1440 images have been simulated and released to the community
 - <https://exoplanets.nasa.gov/exep/technology/starshade-data-challenge/>
 - Broadband observations in 425-552 nm and 615-800 nm
 - Nominal and a “worse” starshade (10x contrast, 2x solar glint)
 - Smooth exozodiacal dust density and resonant cloud structures

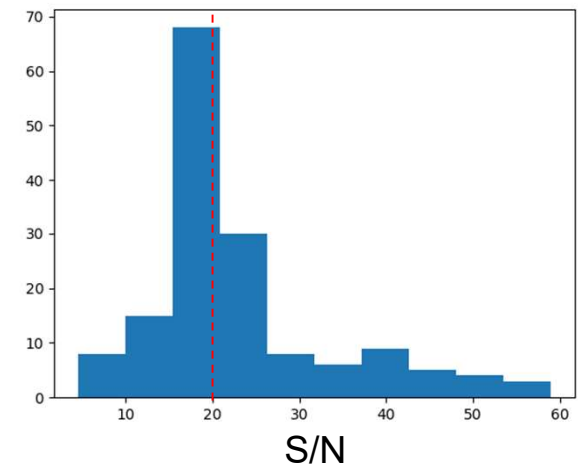
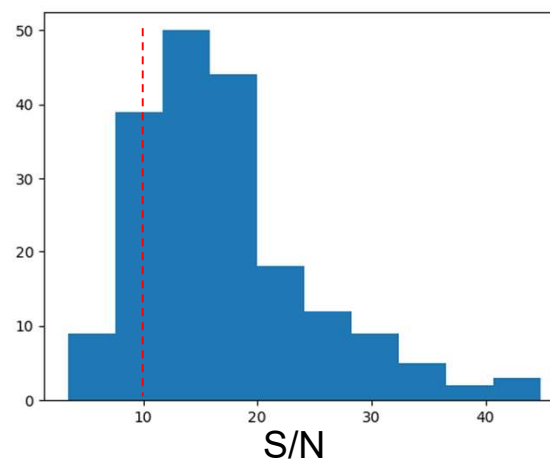
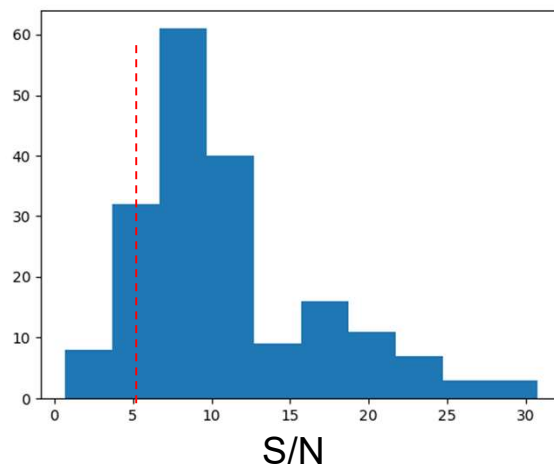


Starshade Exoplanet Data Challenge



ExoPlanet Exploration Program

- Preliminary results:
 - Final reports received from two participating teams
 - Highlights of findings
 - Using a multi-parametric model fit for background removal, most of the inner planets in the simulated images are detected
 - The S/Ns of the detected planets are consistent with the inputs, suggesting background calibration at the photon-noise limit
- Publications
 - Overall design and rationale (Hu et al. 2021 JATIS)
 - Theoretical noise budget of starshade exoplanet imaging (Hu et al. 2021 JATIS)
 - Analysis of the results and high-level implications (Damiano, Hu, et al. 2022, in prep.)

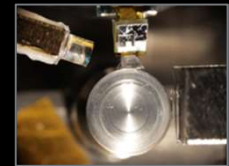


Program Support for Community Exoplanet Observing

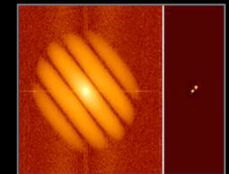
- NASA National Science Foundation (NSF) Exoplanet Observational Research (NN-EXPLORE):
 - NEID commissioned June 2021. Performance of the instrument assessed as excellent; standard stars and solar data released daily
 - The NEID team has submitted/published four journal articles on NEID results, including investigations of GJ 3470 b, WASP-148 b and TOI-1268 b
- High Resolution Imaging Project:
 - The High-Resolution Imaging instrument 'Alopeke successfully observed the first quasi-stellar object (QSO), the faintest target ever done with speckle at Gemini-North
- Southern RV
 - Continue to issue proposal calls and award time each observing semester for SMARTS/Chiron and MINERVA-Australis.
- LBTI
 - ExEP has chosen to conclude the LBTI project as planned
- David Ciardi (NExSci) will talk in more detail on observing resources (NEID, HiRes, Southern RV, Keck)



NN-EXPLORE



*Extreme Precision
Radial Velocity
Technology
Development*



*High Resolution
Imaging*



Keck Observatory

See our website for more info or to join the RCN:
<https://exoplanets.nasa.gov/exep/NNExplore/EPRV-RCN>

EPRV Activities

- NEID solar and standard star data available to the community via the NExSci archive
- EPRV Research Coordination Network (RCN) started
 - Science seminar with EPRV ROSES PIs in April 2022
 - Supported EPRV Splinter at Exoplanets IV
 - Monthly science seminar series began in May 2022
 - Now soliciting ideas for future workshops / seminars



Extreme Precision RV Foundational Science Seminar

Featuring updates and Q&A with the key scientists of NASA's EPRV call on mitigating stellar activity

April 26th, 2022
10am -2pm Pacific

Presented by the

For connection information and more details on



Viva Las Velocities

May 3rd 2022
2:30-5:30pm
Room: Molise 1-2

Connect here :



EPRV Colloquium Series:
May 26 2022, 10a PT / 1p ET / 6p UK
Speaker: Dr. Lily Zhao

"The EXPRES Stellar-Signals Project: Establishing the State of the Field in Disentangling Photospheric Velocities"

Presented by the
EPRV Research Coordination Network



EPRV Colloquium Series:
June 23 26 2022, 9a PT / 12p ET / 5p UK
Speaker: Dr. Suzanne Aigrain

"Towards other earths by way of young Neptunes: data driven stellar variability models for radial velocity planet searches"

Presented by the
EPRV Research Coordination Network

ExEP talks at ExoPAG

- Eric Mamajek: Program Science
- David Ciardi: NExSci
- Brendan Crill: Technology
- Anjali Tripathi: Where We Explore
- Dawn Gelino: NExSS
- Rhonda Morgan: GOMaP - Sci Eval
- Gary Blackwood: GOMaP <-> PAGs
- Nick Siegler: GOMaP - Tech Strategy



***Exoplanets, and the Search for Life, are **Aspirational:**
They Draw us, and Impel us
To **Explore** other Worlds and to **Inspire** our Own***



Jet Propulsion Laboratory
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exoplanets.nasa.gov

Acknowledgements

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