NASA Exoplanet Exploration Program Science Update

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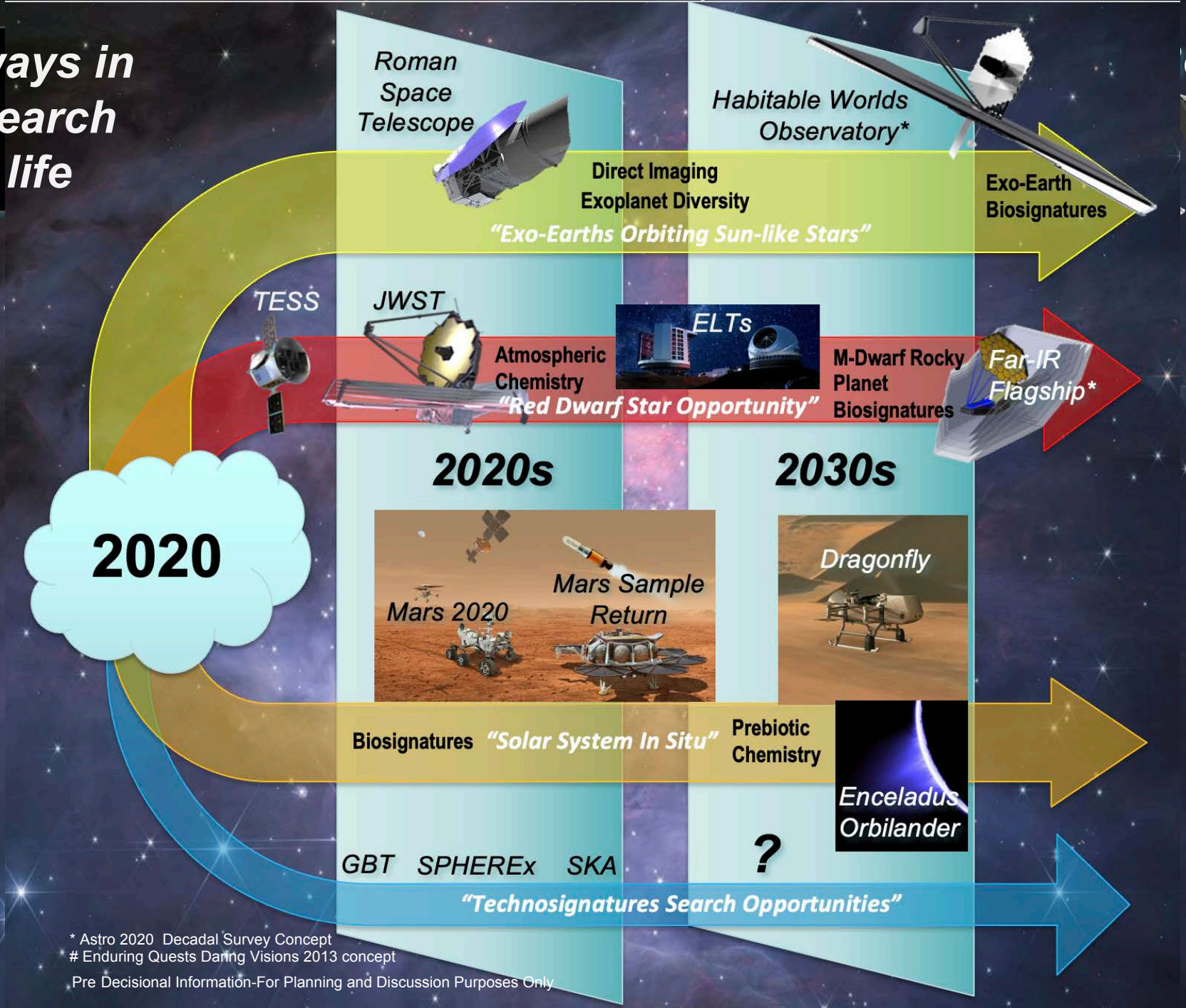
Pathways in the search for life



eyond"

"Exo-Earth Interferometer" #

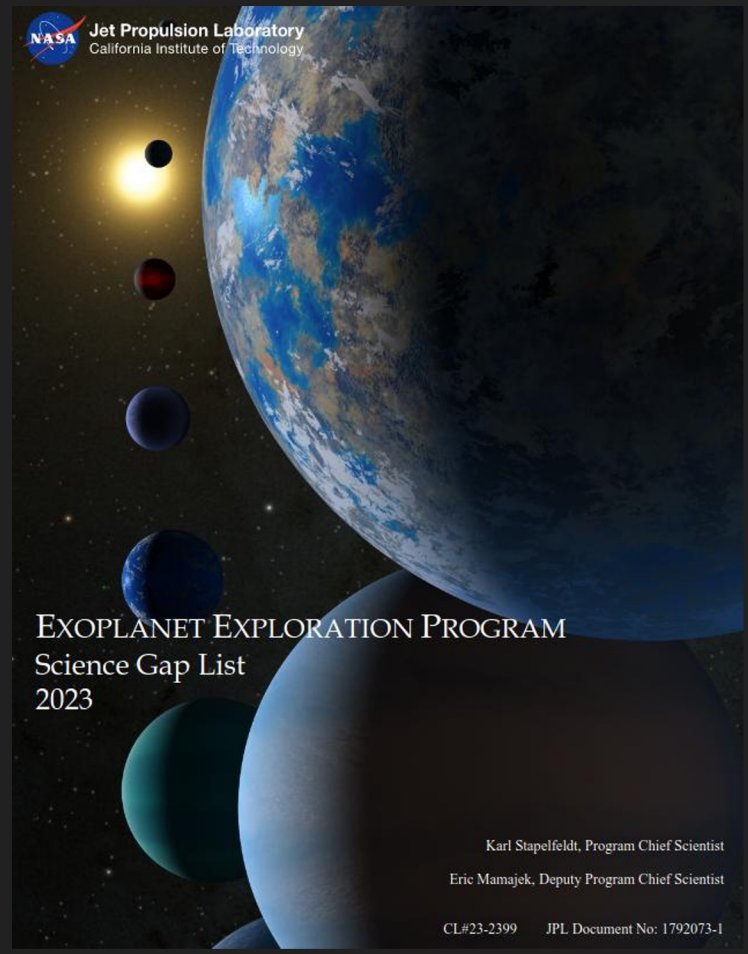
* Astro 2020 Decadal Survey Concept
\# Enduring Quests Daring Visions 2013 concept

NASA Exoplanet Exploration Program Science Gap List

https://exoplanets.nasa.gov/exep/science-overview/

What are the ExEP "science gaps"?

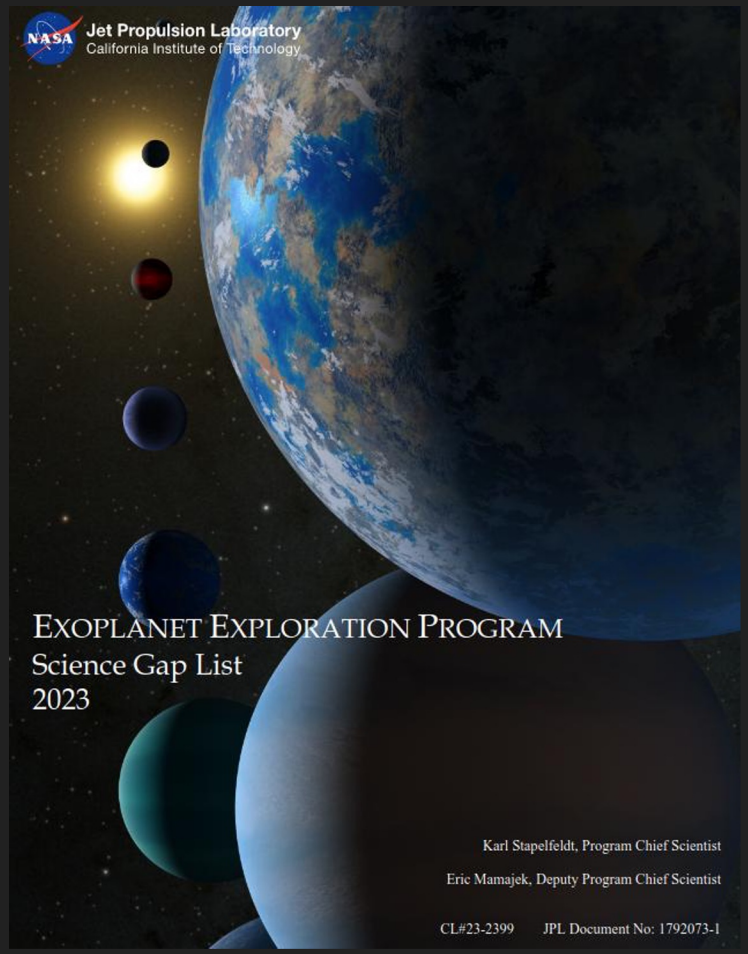
- The difference between knowledge needed to define requirements for specified future NASA exoplanet missions and the current state of the art, or
- Knowledge which is needed to enhance the exoplanet science return of current and future NASA exoplanet missions



NASA ExEP Science Gap List (2023)

https://exoplanets.nasa.gov/exep/science-overview/

- Description of 16 research areas where additional work would benefit current & future NASA exoplanet missions. Tactical goals, flowing from Decadal strategic goals.
- Connects mission needs to work in theory, laboratory measurements, simulations, and supporting observations.
- Its major utility is as a guide for ROSES cross-divisional *Exoplanet Research Program (XRP)* proposers, review panels, and NASA HQ selection officials. Not used proscriptively.
- 2023 update included community input through 2022. 2 new gaps added which were spunoff from prior ones.
- **Opening call for input on 2025 Science Gap List now - deadline Sept 30, 2024. Update posted: Feb 2025**



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2023 ExEP Science Gap List

Each gap is described by:

- * Title
- * Summary
- * Capability Needed
- * Capability Today
- * Mitigations in Progress

"*Mitigations NOT in Progress*" are what one could be proposing to do!

Context for each gap is detailed in the ExEP Science Plan Appendix document, currently under revision

The "other" science gap list : Astrophysics Decadal Survey Precursor Science

- NASA Astrophysics has a new ROSES proposal opportunity to support the definition of the HWO, Far-IR, and X-ray Great Observatories recommended by Astro2020: **D.16 Astrophysics Decadal Survey Precursor Science.** NOIs were due March 29, 2024, proposals were due April 26, 2024

- This opportunity is specific to investigations whose results can affect architecture trades for these three large missions (HWO, far-IR, X-ray); *not preparatory science*

- For the previous 2023 (2022!) proposal opportunity, 18 precursor science gaps were formulated from community inputs, with 8 derived from existing ExEP science gaps. https://exoplanets.nasa.gov/exep/astro2020-precursor-sciws2-roses-call/

- Based on inputs from community to 3 Astrophysics program offices (ExEP, COR, and PhysCOS), NASA HQ posted a new "science gaps worksheet" in February 2024 to inform the latest round of proposals (posted at ROSES D.16 site).

- 30 science gaps total, of which 10 are relevant to Habitable Worlds Observatory exoplanets + survey for potentially habitable worlds (mostly overlap existing ExEP science gaps)

Exoplanet-related ROSES 2022 Precursor Science Selections

Principal Investigator	Proposal Title
Bryson, Stephen *NASA Ames*	Obtaining Better Constraints on Eta-Earth by Reprocessing Kepler Data to Generate a More Complete and Reliable Exoplanet Catalog
Courtney Dressing *University of California, Berkeley*	A Pathway to Planet Properties
Steve Ertel *University of Arizona*	Securing revolutionary exozodi research with VLTI/NOTT
Joshua Krissansen-Totton *University of Washington*	Determining the Habitable Worlds Observatory capabilities needed to corroborate oxygen biosignatures
Meredith MacGregor *University of Colorado*	Unraveling the Disk - Sensitivity, spectral and spatial resolution requirements for accurate determinations of disk masses
Dmitry Savransky *Cornell University*	Open Source Tools for Mapping Exoplanet Science Goals to Architecture Properties of the IR/O/UV Great Observatory
Margaret Turnbull *SETI Institute*	Quantifying Spectroscopic Performance Requirements for Detecting Biosignatures with a Habitable Worlds Observatory
David Wilson *University of Colorado*	Stellar X-ray and Ultraviolet characterization of the Habitable Worlds Observatory habitable planet target sample

Provisional ExEP target star list for *Habitable Worlds Observatory* precursor science: The most accessible nearby habitable zones

https://exoplanets.nasa.gov/exep/science-overview/ https://arxiv.org/abs/2402.12414

Selection criteria:

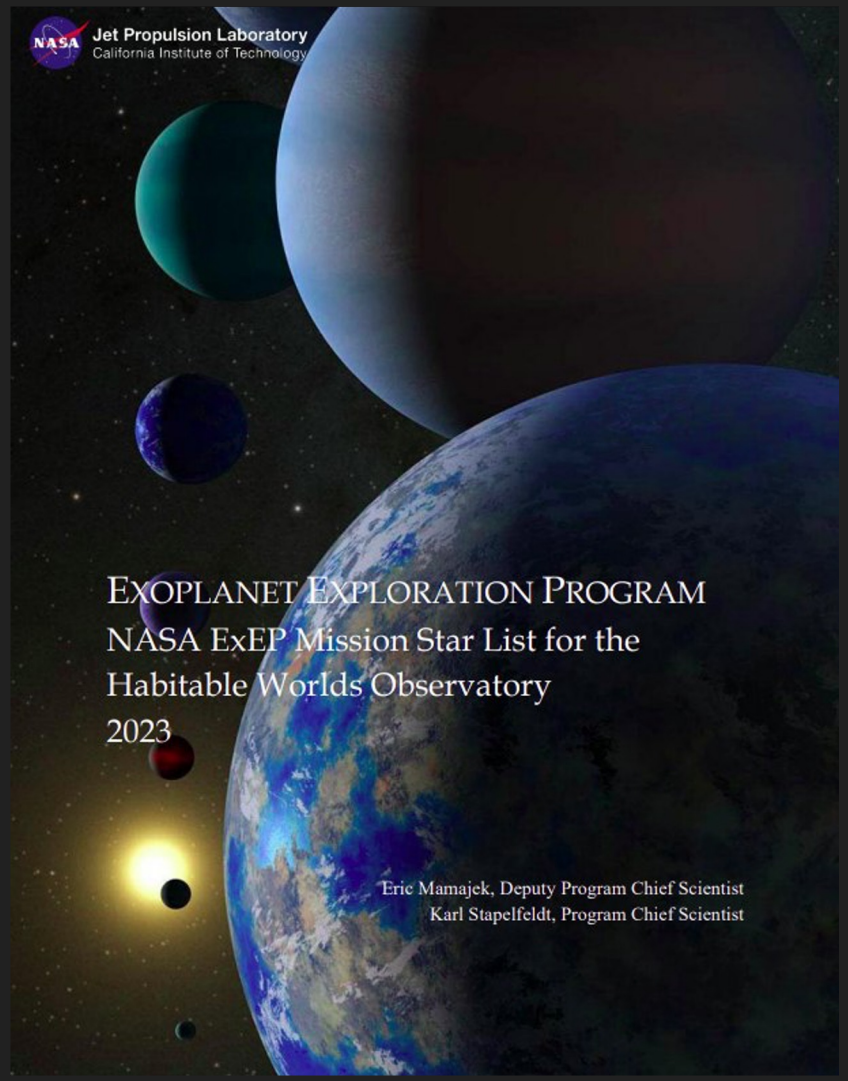
1. HZ Earth analog bright enough for spectroscopy with 6m telescope in <2 months integration time
2. Detection contrast consistent with Program technology goals
3. Inner Working Angle sufficient to achieve the Astro2020 goal of characterizing ~25 HZ rocky planets

Parameter	Tier A	Tier B	Tier C
IWA constraint	83 mas	72 mas	65 mas
Exoplanet brightness limit (Rc)	30.5 mag	31.0 mag	31.0 mag
Exoplanet-star Brightness ratio limit	4e-11	4e-11	2.5e-11
Disk criterion	No known dust disks of any kind	No disk, or KB disks OK if Ldisk/L* <= 10^{-4}	All disks OK, even if Ldisk/L* >=10^{-4} or detected HZ warm dust disk
Treatment of binaries	Single or binary companion > 10" sep	Single or binary companion > 5" sep	Single or binary companion > 3" sep
Number of Stars	47	51	66

Sample	F	G	K	M
Tier A	14	15	17	1
Tier B	15	23	11	2
Tier C	37	17	12	0
Total (A+B+C)	66	55	40	3

Approx. magnitude & distance limits:

F*s: Vmag < 6.0, d < 23.3 pc
G*s: Vmag < 6.4, d < 20.5 pc
K*s: Vmag < 7.0, d < 12.8 pc
M*s: Vmag < 7.5, d < 4.0 pc



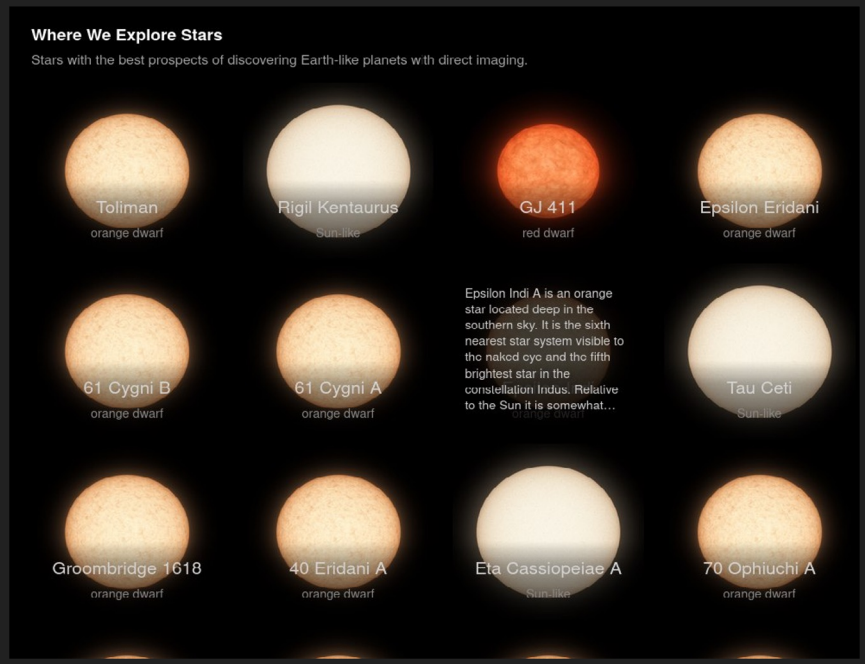
Provisional ExEP target star list for HWO precursor science: Progress since the February 2023 release

https://exoplanets.nasa.gov/exep/science-overview/

- Queryable table of ExEP HWO target star list is available through NASA Exoplanet Archive https://exoplanetarchive.ipac.caltech.edu/ under “HWO ExEP Precursor Science Stars”
- For the ExEP Coronagraph Technology Roadmap Team UV task group (Juanola-Parramon et al.), we studied the accessibility of the target stars in the near-UV ozone band. For ~40 of the stars, a HZ Earth analog would appear to be too faint to measure with HWO – most of the K and M stars.
- Received community input on additional stellar parameters & photometry to add which would be helpful, however the **Target Stars & Systems (sub-)Working Group** (EEM co-chairing w/Natalie Hinkel (LSU)) may provide further input in coordination with other START/TAG teams (especially Exoplanet Yields Working Group)

You can now find the provisional HWO precursor stars in Eyes on Exoplanets

https://eyes.nasa.gov/apps/exo/



- Eyes on Exoplanets is a visualization tool of known exoplanetary systems
- By selecting "Earth" as the viewing point, any geographical point as your location, and the "Future Target Stars" you can get to know the individual target systems the HWO is likely to explore. They are the circles w/o diffraction spikes in the animated starfield above left.
- Alternatively, by selecting "Browse Destinations", and then "Stars", you can see depictions of the likely HWO targets, and text descriptions of their properties and presence in popular culture

Exoplanet Science Metrics for the Habitable Worlds Observatory

- Many aspects of exoplanet science could affect the HWO architecture selection, beyond Astro2020's goal of spectrally characterizing ~25 temperate rocky exoplanets – the only exoplanet science metric established so far for HWO
- To gather ideas on other possible metrics, the ExEP Science Office convened a working group which was active in spring and summer 2023, including a splinter session at AAS 242 (Albuquerque)
- Participating community members developed detailed write-ups on the suggested metrics at right. *Thanks much for their efforts !*
- We will ask the HWO/START Exoplanet Imaging Yields Subgroup to continue development of multiple exoplanet science metrics, these and others yet to be discussed

Champion	Metric idea
Eliza Kempton (U. of Maryland)	Comparative atmospheres of rocky exoplanets
Nancy Kiang (GSFC/GISS, ExEP visitor)	Detecting photosynthetic pigments
Jake Lustig-Yeager (APL)	Detecting exoplanet rotational variability
Avi Mandell (GSFC)	Water band search
Michael Meyer (U. of Michigan)	Hypothesis testing with system architecture subsamples
Ty Robinson (U. of Arizona)	Detecting surface oceans from glint

Selected Highlights Since January / ExoPAG 29

Exoplanet Archive
https://exoplanetarchive.ipac.caltech.edu/

- Released Stellar Hosts table
- Inclusion of projected angular separations in planetary systems composite parameters table
- New interactive plotting capabilities

ExoFOP (Exoplanet Follow-up Observing Program)
https://exofop.ipac.caltech.edu/tess/

- Inclusion of HWO Target Stars
- User Table Preferences

Sagan Summer Workshop: 22-26 July 2024
https://nexsci.caltech.edu/workshop/2024/

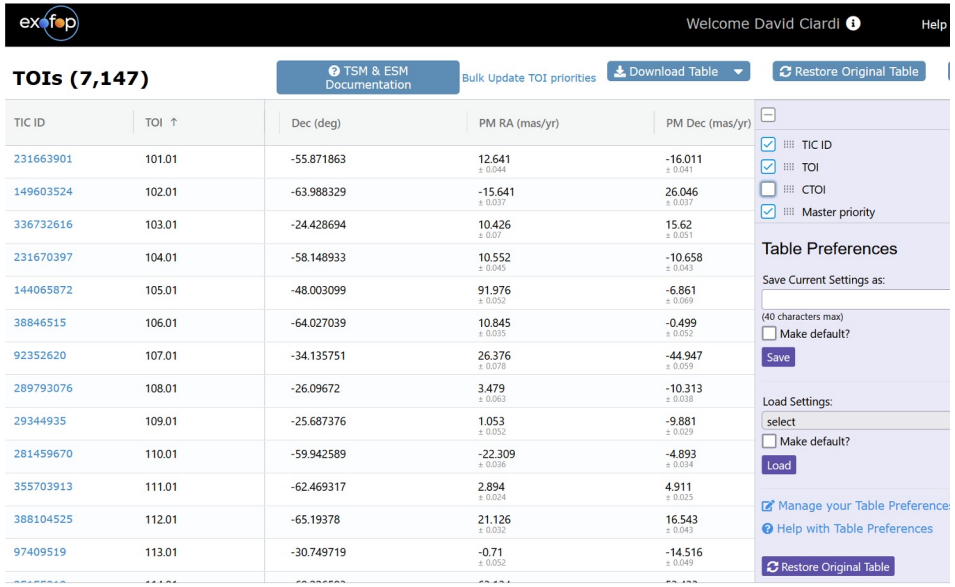
- Advances in Direct Imaging: From Young Jupiters to Habitable Earths
- Registration still open: In-person: 298, Total: 1176

NASA Keck Time & Keck Observatory Archive
https://koa.ipac.caltech.edu/

- 1 joint JWST-Keck proposal selected for Cycle 3 + 2025A
- KPF (Keck Planet Finder) data included and available through interfaces

Dr. Dawn Gelino, Deputy Director, is now ExEP Program Manager

- Science Affairs Lead position will be advertised this month
- Anticipate Exoplanet Archive Staff Scientist position to be advertised this month



Backup slides

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.

Selected Highlights Since January

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