ESA Voyage 2050 Status (Focus on Exoplanets)

A. Quirrenbach

Voyage 2050: Goals

- Select scientific topics (not missions!) for ESA long-range planning
- Define science for two large missions (L4/L5), three medium-sized missions (M7/M8/M9), and one fast/flexi mission (F3) to be launched in the time frame 2035-2050
- Identify promising technologies that need further development
- Note: Scope is all of astronomy, Solar system science (including space plasma physics), and fundamental physics

Voyage 2050: Process

- Senior Committee and Topical Teams established in 2018/2019
  - Members selected from the community
- Solicitation of White Papers from the community (deadline August 2019), 95 WPs received
- Workshop with White Paper presentations (October 29-31, 2019)
- Evaluation of White Papers by Topical Teams
- Topical Teams report to Senior Committee (February 2020)
- Senior Committee recommendations to Director of Science (mid-2020)

Topical Teams

1. Solar and Space Plasma Physics
2. Planetary Science
3. **Galaxy, Star and Planet Formation and Evolution; Astrochemistry and the ISM**
4. The Extreme Universe, including Gravitational Waves, black holes, and compact objects
5. Cosmology, Astroparticle Physics and Fundamental Physics

ESA Mission Classes

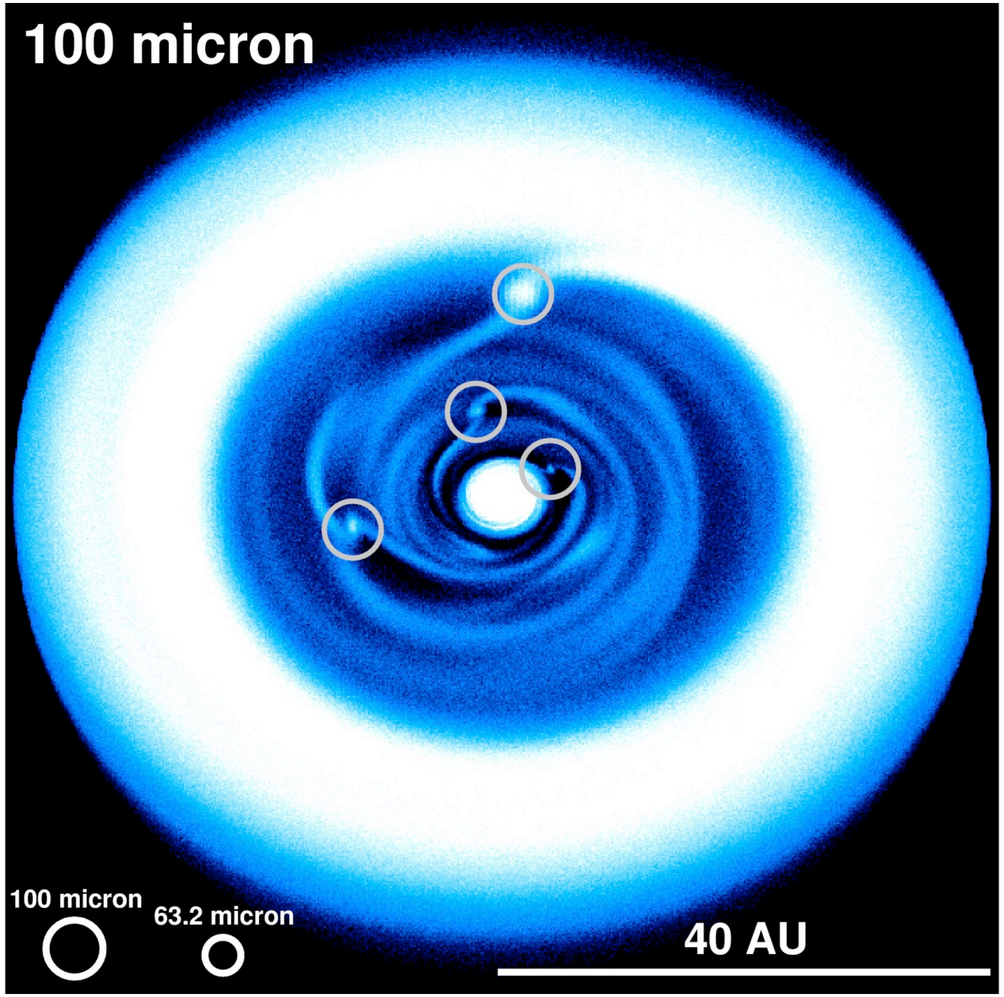
- Large (L-Class) “Flagship”, one per decade
  - Budget up to ≈ 1 G€
  - Must be led by ESA (resilience against failure of a partner to deliver)
- Medium (M-Class)
  - Budget up to ≈ 600 M€
  - Can be contribution to mission led by partner agency (e.g., NASA)
- Fast (F-Class) new line, first call in 2018
  - Budget up to ≈ 150 M€
- Small (S-Class)
  - Budget up to ≈ 50 M€, larger national contributions
- Note: “Budget” in the above is cost to ESA only
  - Contributions by member states are usually expected; value is sometimes almost as big as ESA budget

Exoplanets: A Rapidly Evolving Field

- 1995: First planet around Sun-like star confirmed
- < 2000: Surprise, surprise (hot Jupiters, high e, …)
- < 2010: Orbits, systems, transits
- < 2020: Statistics, atmospheres, Earth twins (almost)
- < 2030: Details, taxa, Earth twins (real!)
- Voyage 2050: Habitability and Life

Great Exoplanet Missions are Usually General-Purpose Observatories

- Spitzer , Hubble, JWST
- CoRoT, Kepler, TESS, Plato
- Gaia, future astrometry
- WFIRST
- Large UV-optical telescope (e.g. HabEx, LUVOIR)
- Mid-IR / far-IR interferometer



Relevant White Papers Submitted

M. Barstow / C. Evans	**The search for living worlds and the connection to our cosmic origins**
J.-L. Bertaux	**Exploring the nearest habitable exoplanets**
A. I. Gómez de Castro	**EUVO – The UV window into the universe**
P. Horzempa	**Precise astrometry: earth analogs and beyond**
K. Jahnke	**The need for a multi-purpose, optical-NIR space facility after HST and JWST**
M. Janson	**Prospects for studying earth-like planets with the E-ELT and a space-based occulter**
H. Linz	**Bringing high spatial resolution to the far-infrared**
F. Malbet	**Faint objects in motion: the new frontier of high precision astrometry**
P. Plavchan	**EarthFinder**
S. Quanz	**Atmospheric characterization of terrestrial exoplanets in the mid-infrared:**
L. Rossi	**Spectropolarimetry as a tool for understanding the diversity of planetary atmospheres**
J. Schneider	**Very high resolution spectro-polarimetric interferometry and imaging from the moon**
I. Snellen	**Detecting life outside our solar system with a large high-contrast-imaging mission**
M. Wiedner	**Origins Space Telescope: from first light to life**

J.-L. Bertaux

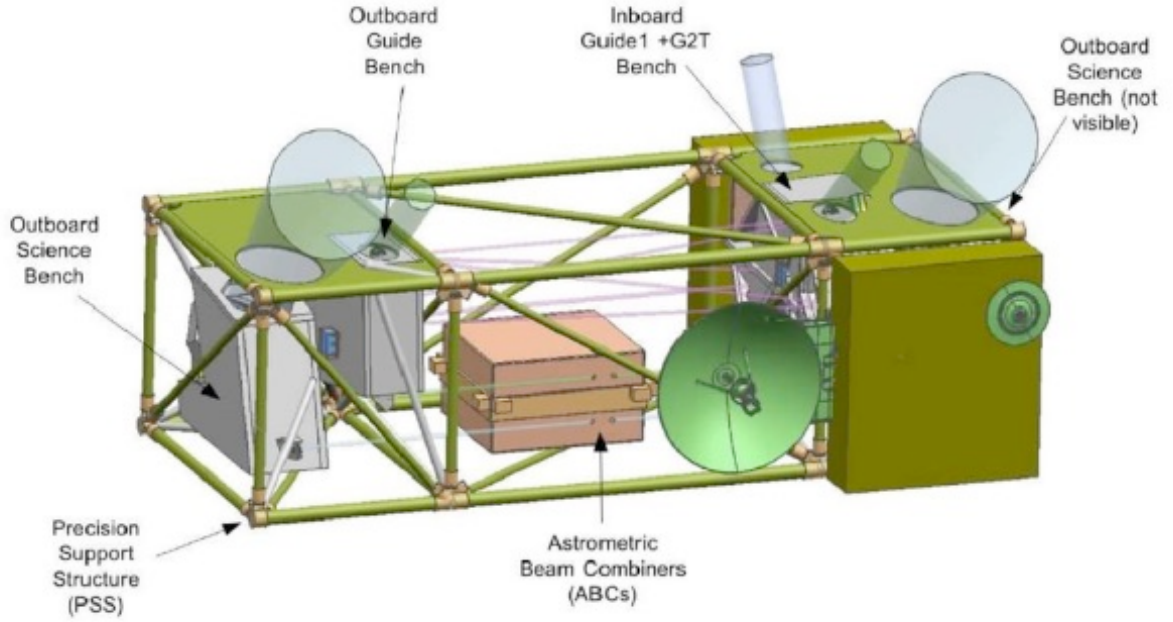
Exploring the nearest habitable exoplanets

- Look for potentially habitable planets from the ground
- Space is needed for characterization
- Consider biosignatures and technosignatures
- Cooperate with NASA

P. Horzempa

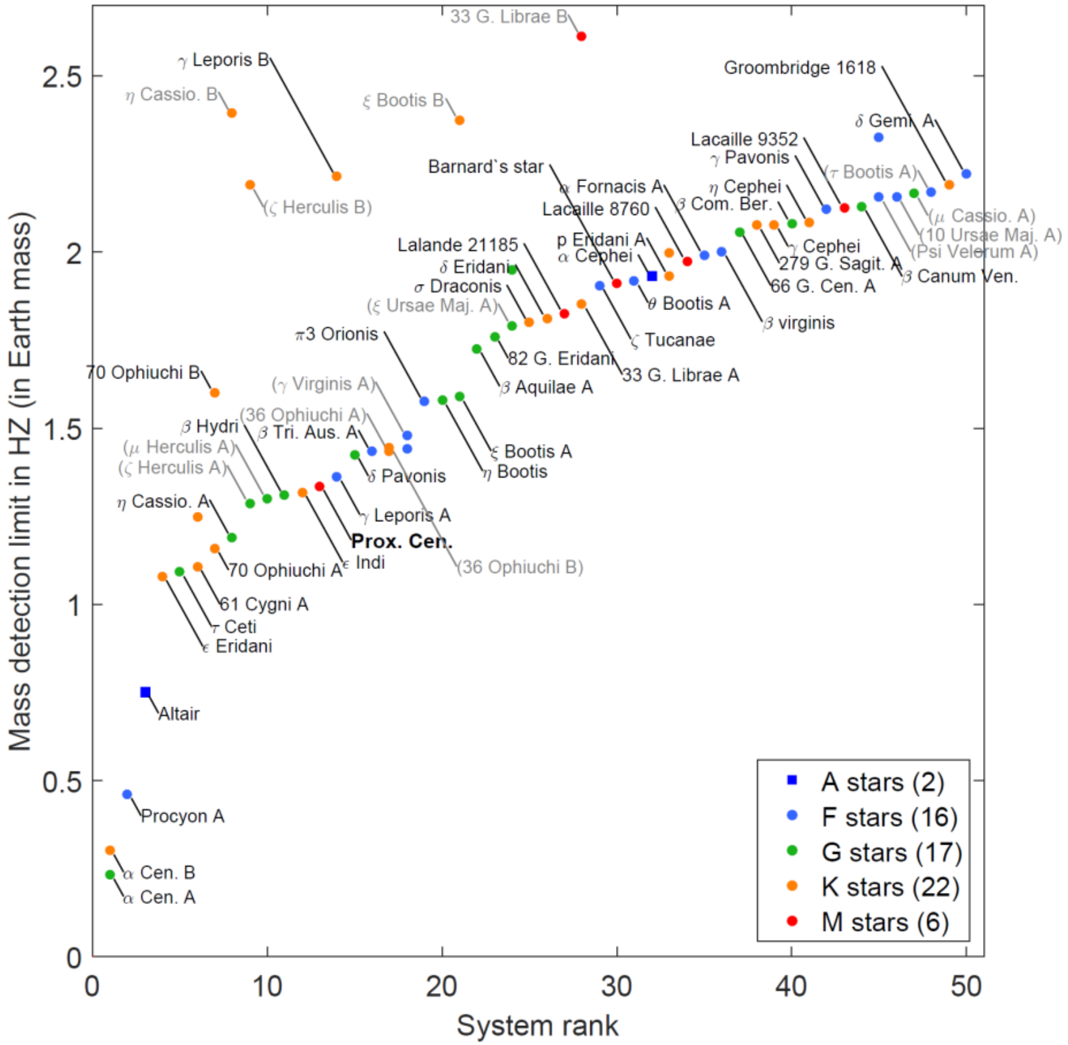
Precise astrometry: earth analogs and beyond

- Astrometric detection and mass measurement of exoplantes
- Precision ≈ 0.3 μas
- Compelling general astrophysics
- Build on expertise and hardware developed by NASA (SIM)



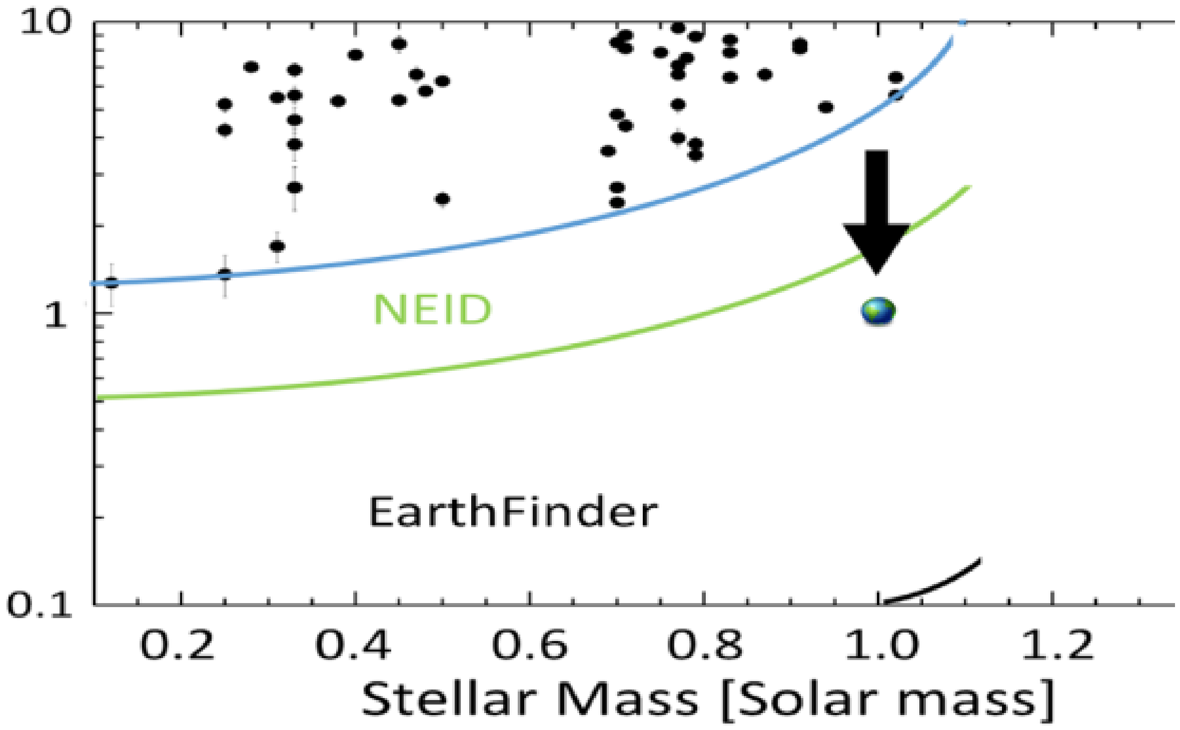
F. Malbet Faint objects in motion: the new frontier of high precision astrometry

- M-class targeted astrometry mission
- ≈ 0.15 µas precision at $V = 5$
- Broad science case
- Discovery, masses and orbits of Earth analogs



P. Plavchan
EarthFinder

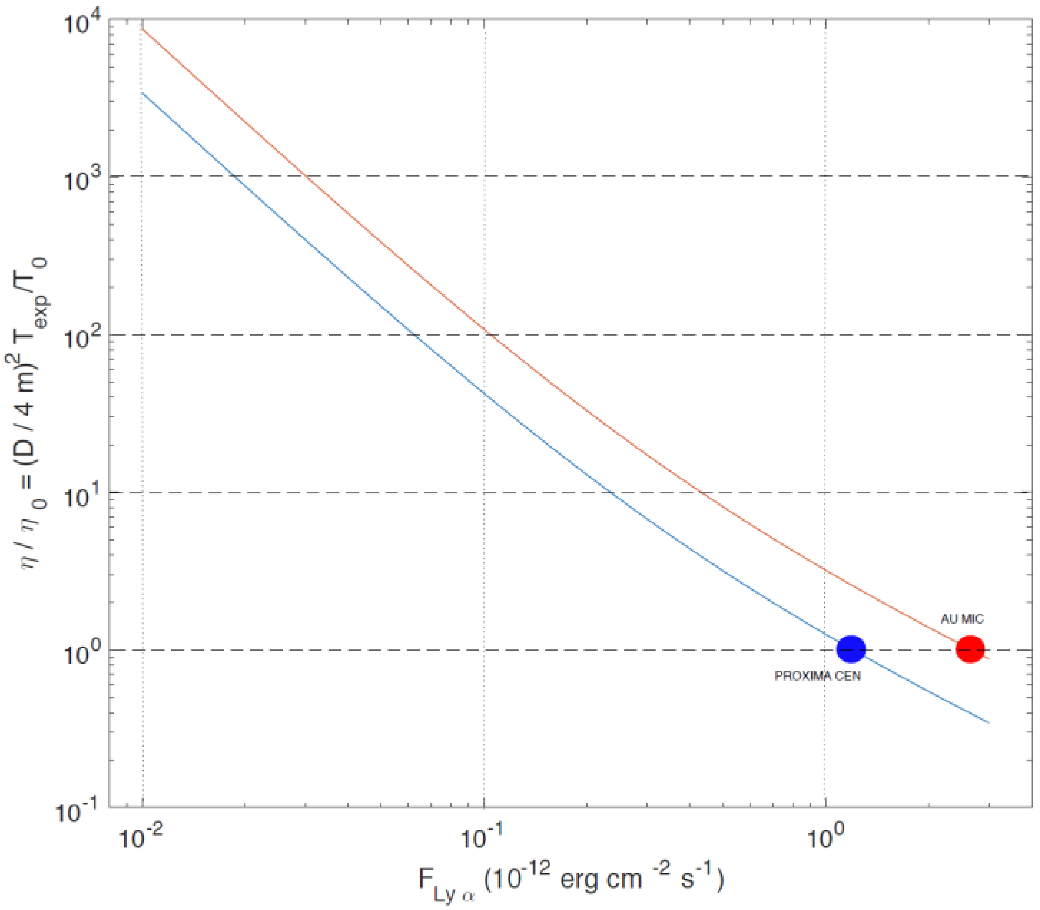
- Radial velocities from space
- No telluric contamination
- Access to visible / NIR to mitigate stellar activity
- ≈ 1 cm/s precision
- Study for NASA Probe class mission



A. I. Gómez de Castro

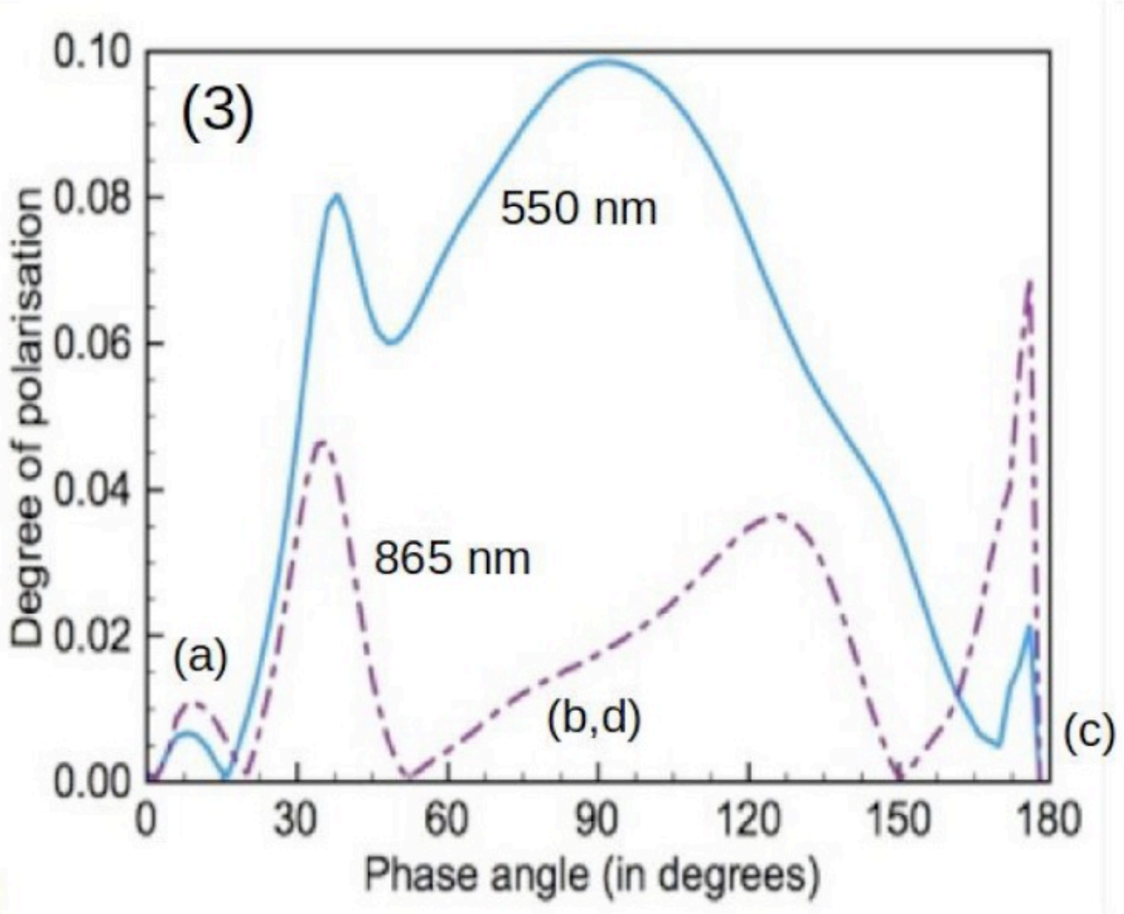
EUVO – The UV window into the universe

- UV diagnostics of exoplanet atmospheres
- Evaporating planets
- Implications for habitability of Earth-like planets



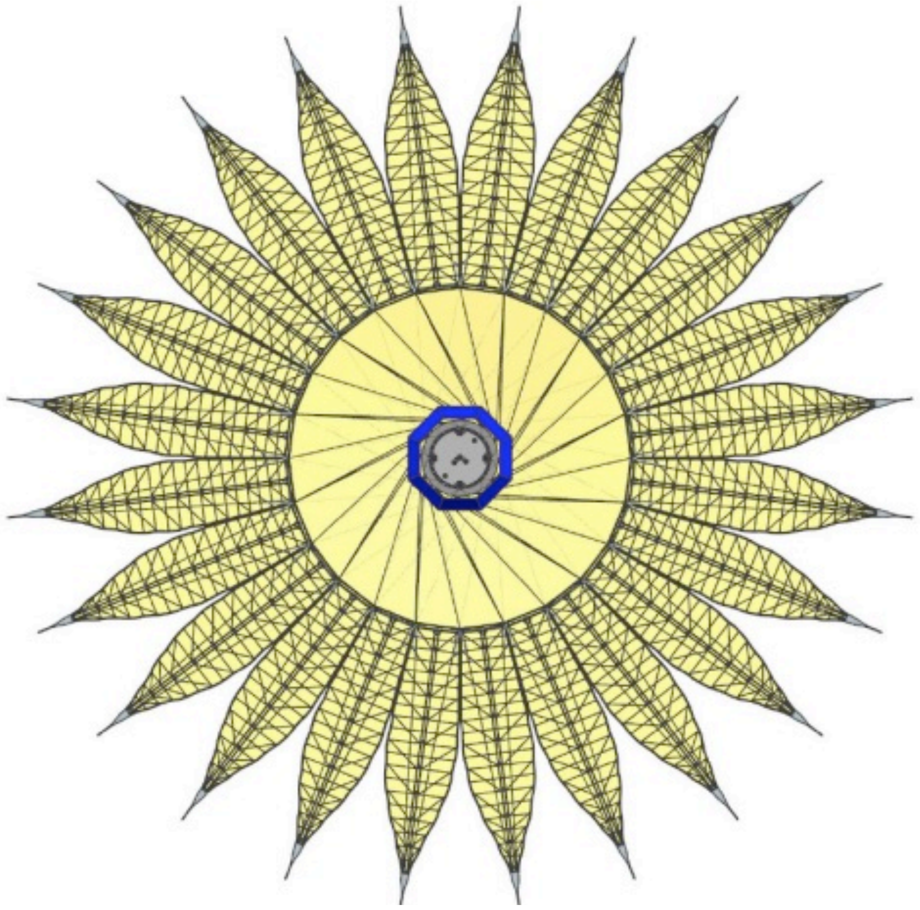
L. Rossi Spectropolarimetry as a tool for understanding the diversity of planetary atmospheres

- Light reflected by planets is highly polarized
- Detailed studies of atmospheric composition
- L class mission
- Coronograph or external occulter



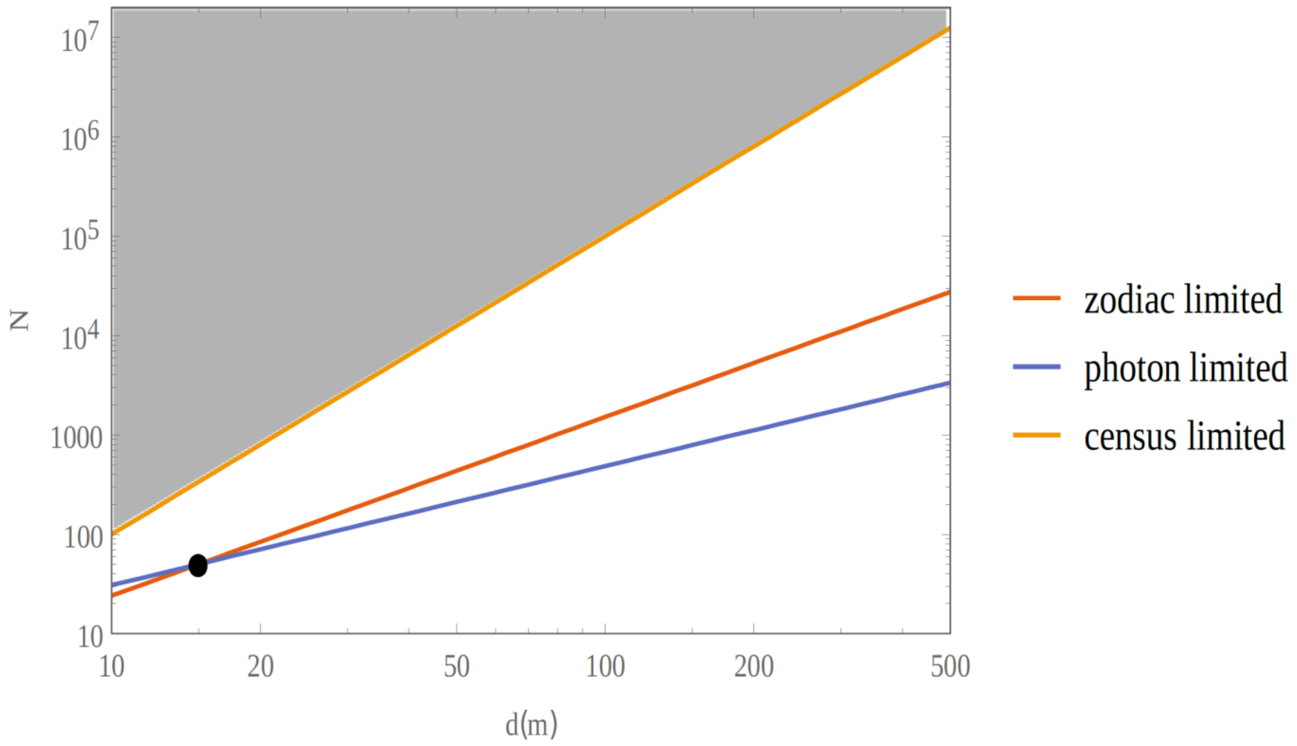
M. Janson Prospects for studying earth-like planets with the E-ELT and a space-based occulter

- ≈ 100 m Occulter for high-contrast imaging and spectroscopy
- Use with E-ELT
- Special orbits to achieve long integration times



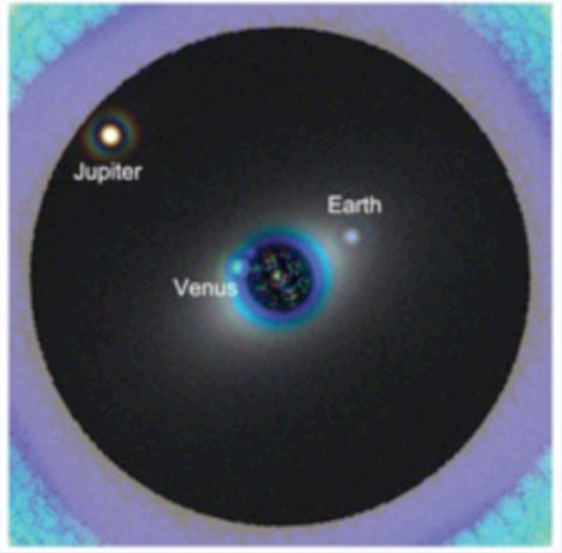
J. Schneider **Very high resolution spectro-polarimetric interferometry and imaging from the moon**

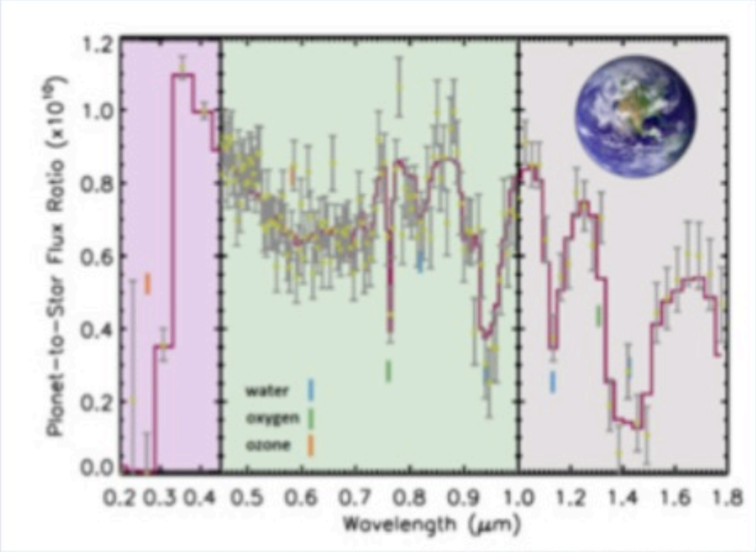
- Frequency of life, photosynthesis, multicellularity, technology
- OWL-like telescope on the Moon
- Also intensity interferometry between Earth and Moon



Characterizing Terrestrial Exoplanets:

The Case for a Large High-Contrast-Imaging Mission





LUVOIR, HabEx Reports

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Characterizing terrestrial exoplanets: The case for a Large Mid-Infrared Interferometry Mission

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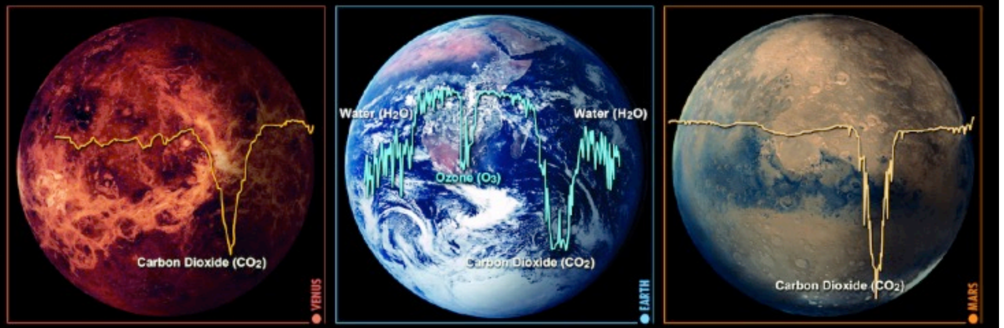


ESA Voyage 2050 workshop
CSIC, Madrid, Spain, 29-31 October, 2019

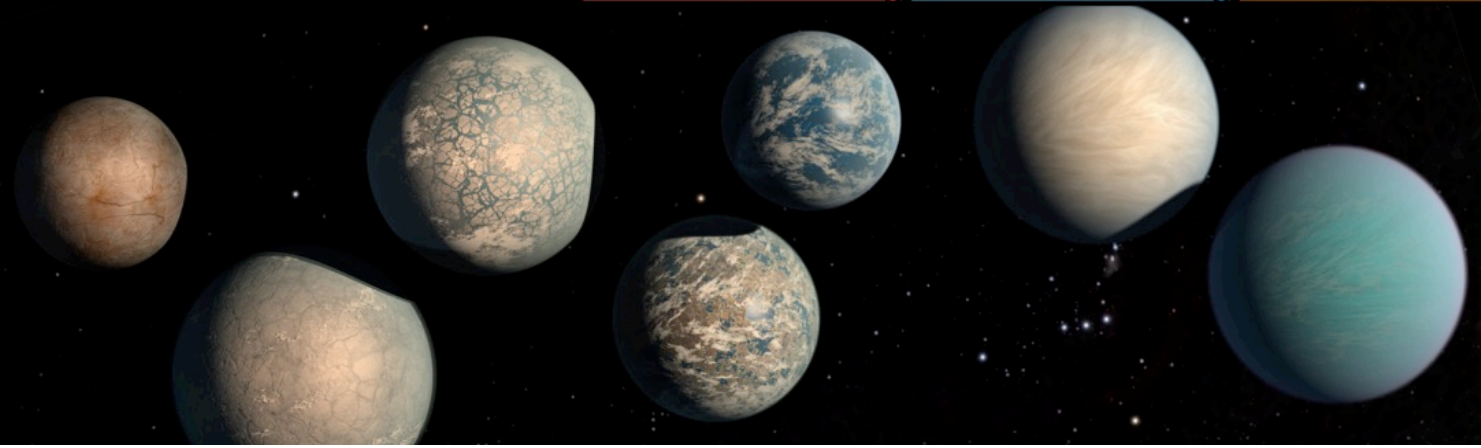


Image credit: NASA/JPL Caltech; ESA Medialab

The Search for Living Worlds

& The Connection to Our Cosmic Origins

Chris Evans (UKATC)

White Paper led by Martin Barstow (Leicester)

Team: Aigrain, J. Barstow, Barthelemy, Biller, Bonanos, Buchhave, Casewell, Charbonnel, Charlot, Devany, Ferrari, Fossatti, Gänsicke, Garcia, Gomez de Castro, Henning, Lintott, Knigge, Neiner, Rossi, Snodgrass, Stam, Tolstoy, Tosi

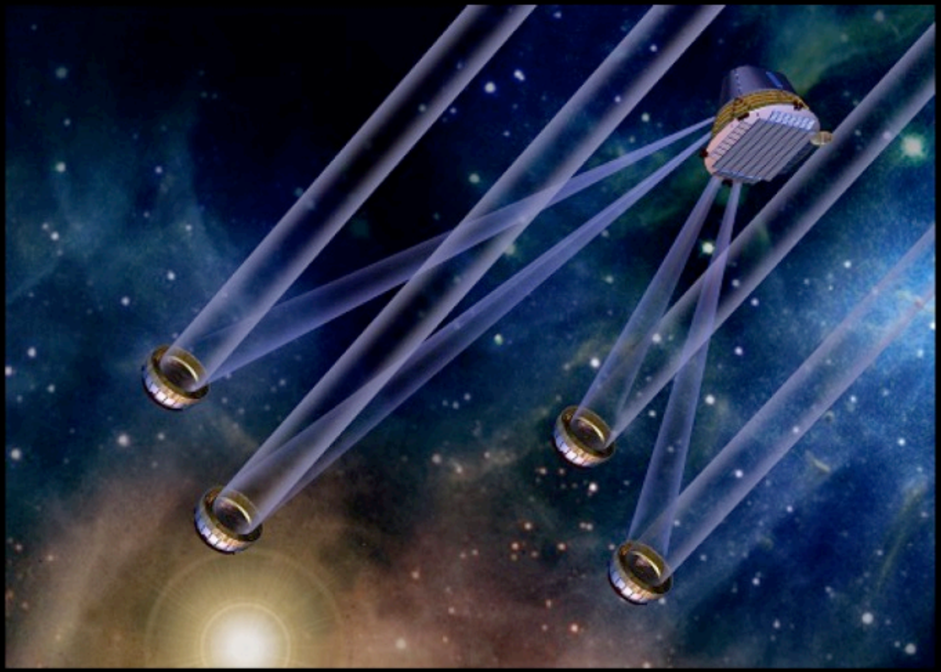
The need for a multi-purpose, optical–NIR space facility after HST and JWST

The case for an ESA-led HabEx Workhorse Camera

Knud Jahnke, Oliver Krause, Hans-Walter Rix (MPIA)

Bringing high resolution to the Far-Infrared

Hendrik Linz (MPIA Heidelberg)
on behalf of the High-res FIR author team



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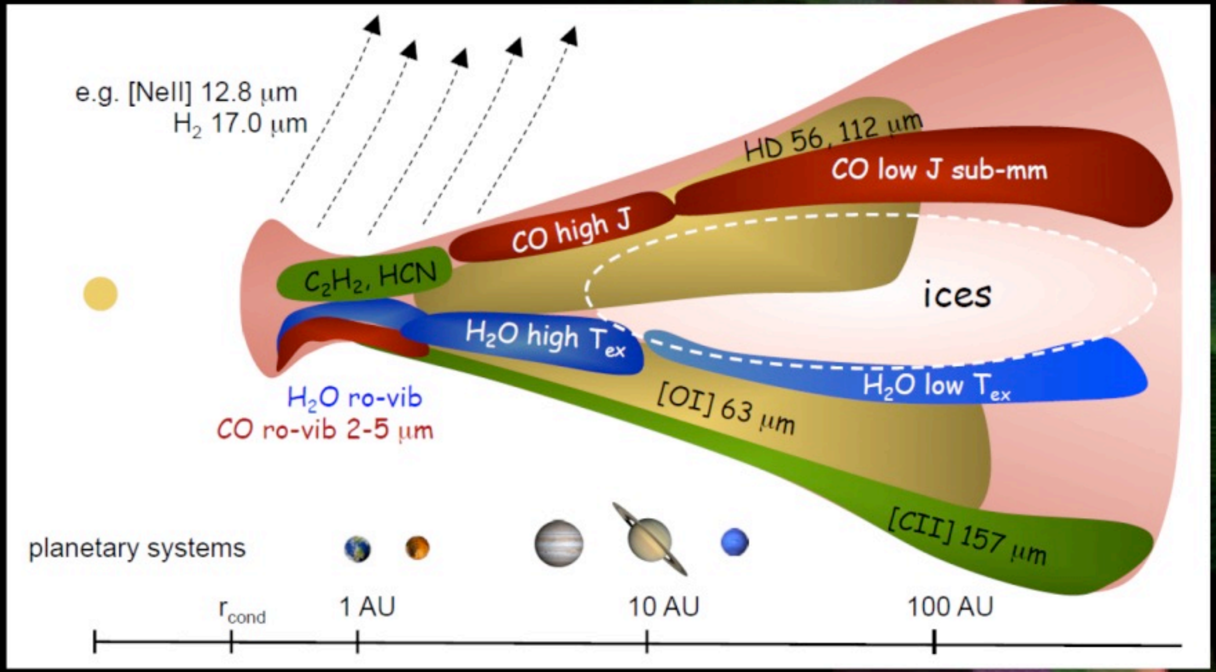

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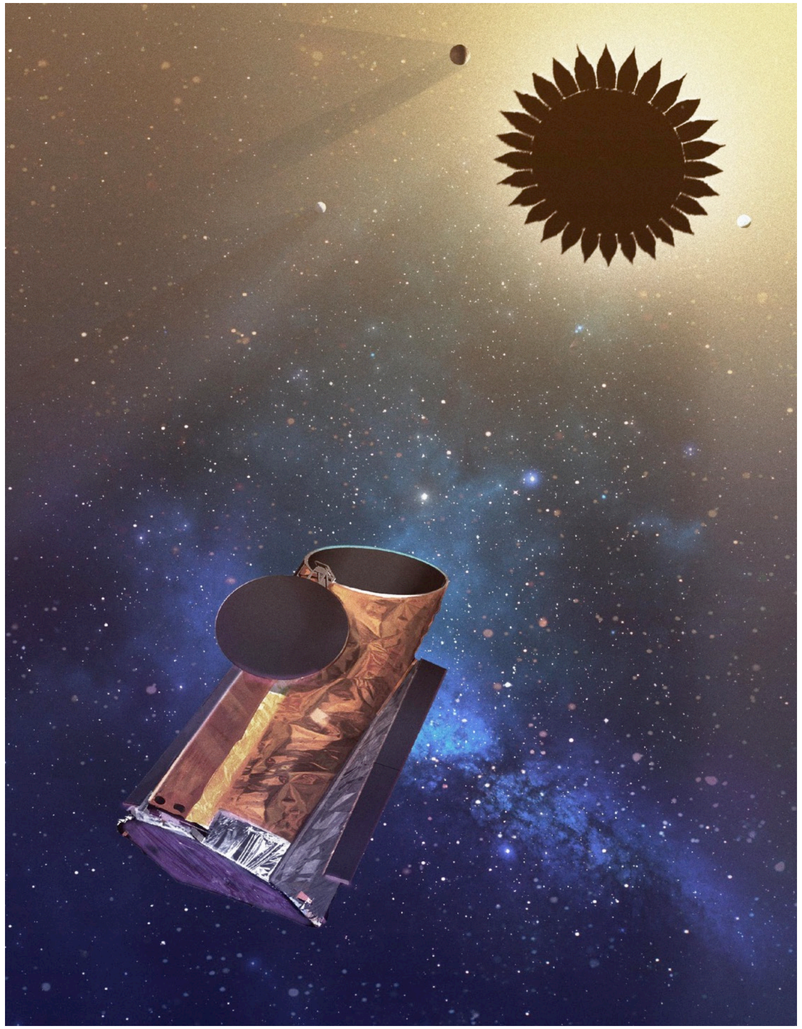
ORIGINS Space Telescope

Martina Wiedner (Paris Observatory) for the Origins Team

HabEx and LUVOIR

- Two of four studies funded by NASA for 2020 decadal survey
- Coronograph and/or occulter
- Not two competing missions
- Largely overlapping science addressed from two angles
- “Realistic” vs. “very ambitious”
- 2.4 m to 15 m telescopes studied



Europe and HabEx / LUVOIR

- Large UV-optical telescope in space
- Broad appeal including strong exoplanet science
- European members of study teams appointed by several national agencies
- Opportunities for ESA to join (M-level commitment?)
- Contributions to mission and instruments
- Follow successful HST / JWST approach

Future ESA Space Science Missions

Last update: December 2018