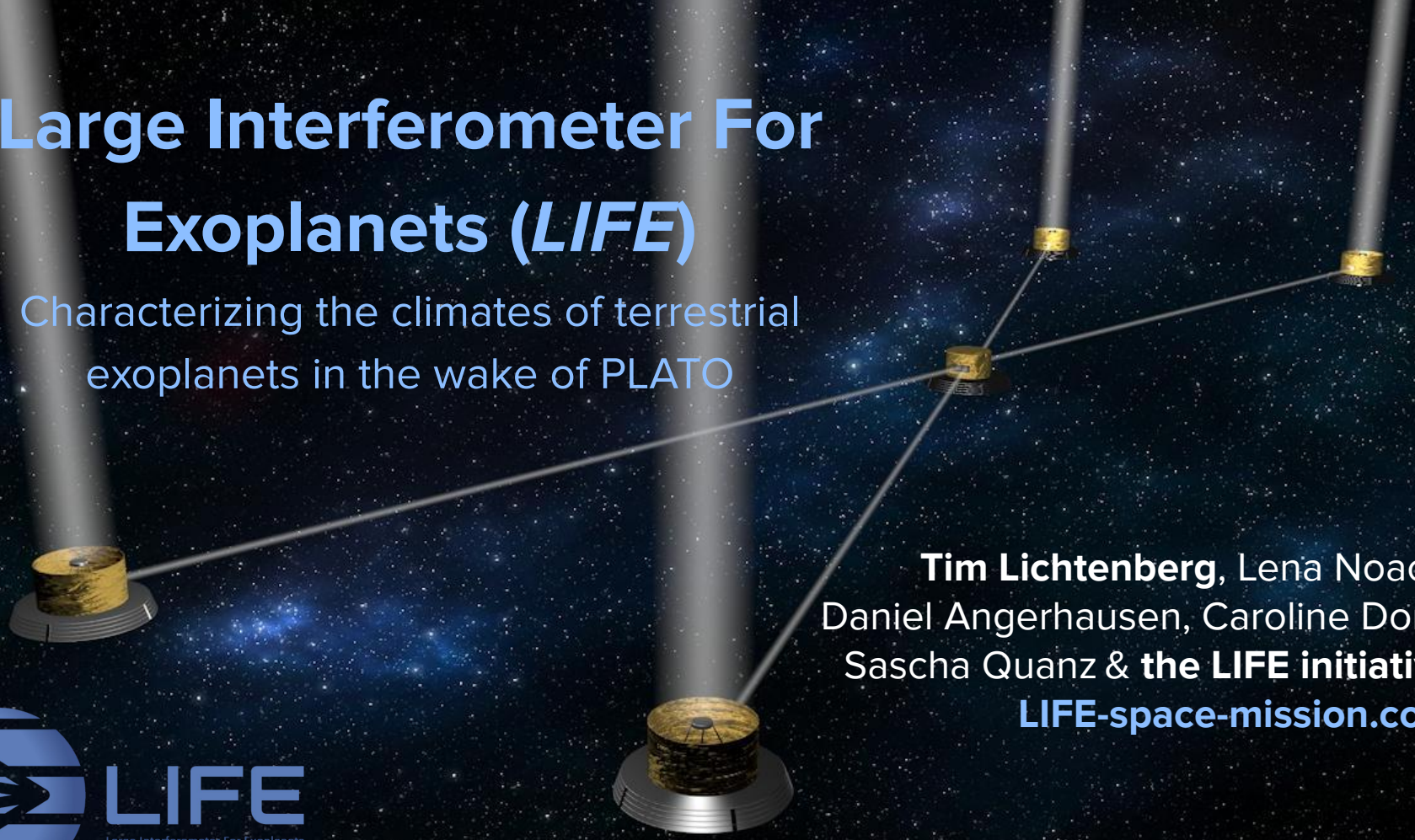
Large Interferometer For Exoplanets (*LIFE*)

Characterizing the climates of terrestrial exoplanets in the wake of PLATO



Tim Lichtenberg, Lena Noack, Daniel Angerhausen, Caroline Dorn, Sascha Quanz & **the LIFE initiative**

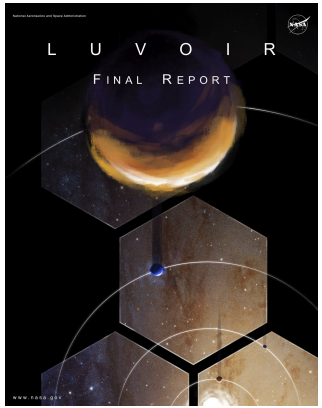
LIFE-space-mission.com

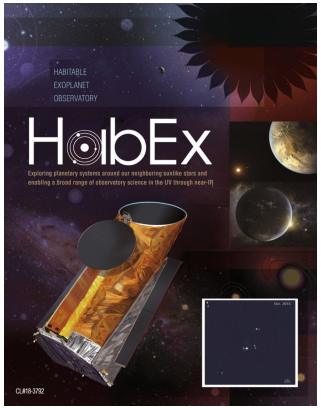
LIFE
Large Interferometer For Exoplanets

PLATO Mission Conference 2021

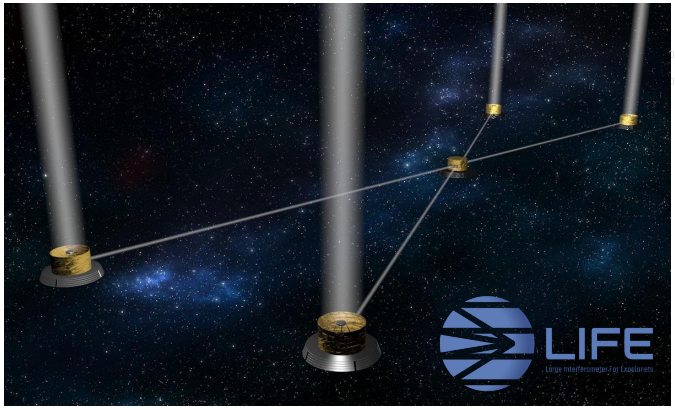
Direct detection: the day after tomorrow

Reflected light
UV & NIR



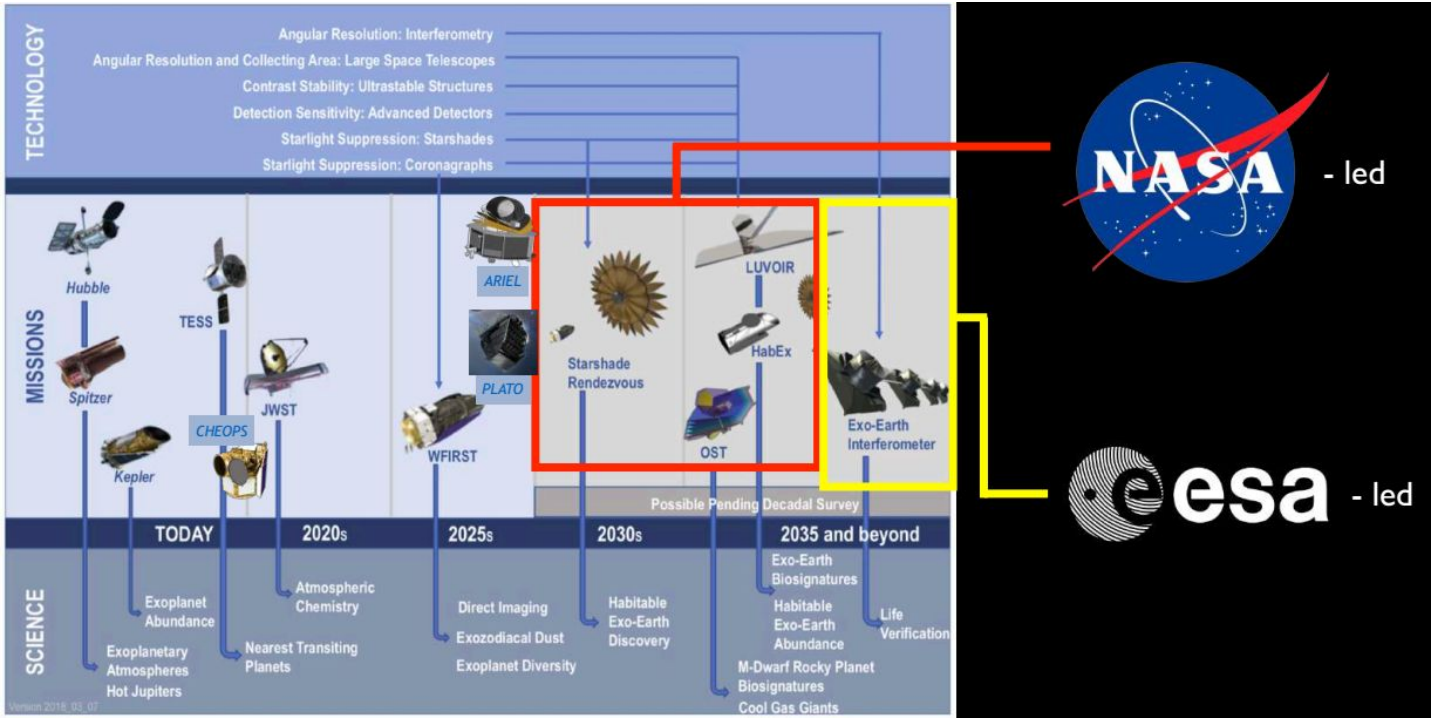


Thermal Emission
MIR



Countdown to the NASA Decadal Survey 2021 report

International roadmap



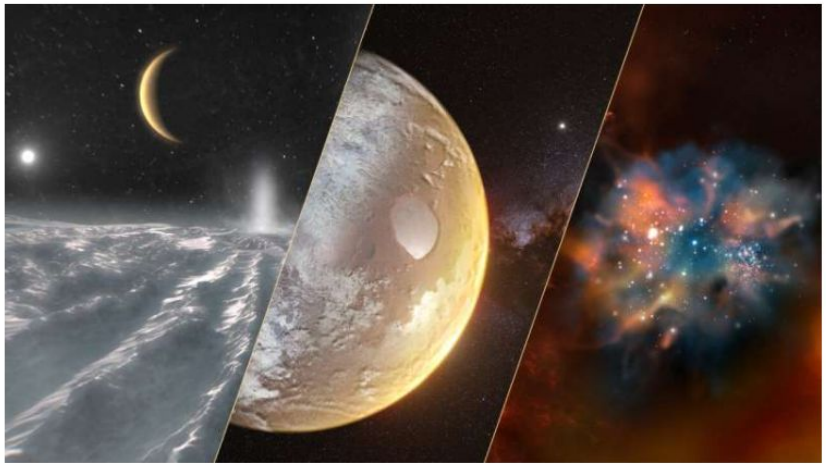
Adapted from NASA/JPL/Caltech; https://exoplanets.nasa.gov/exep/technology/technology-overview/ (July 4, 2019)

ESA roadmap

JUNE 11, 2021

Voyage 2050 sets sail: ESA chooses future science mission themes

by European Space Agency

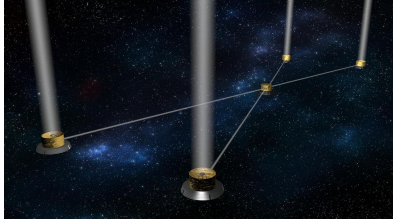


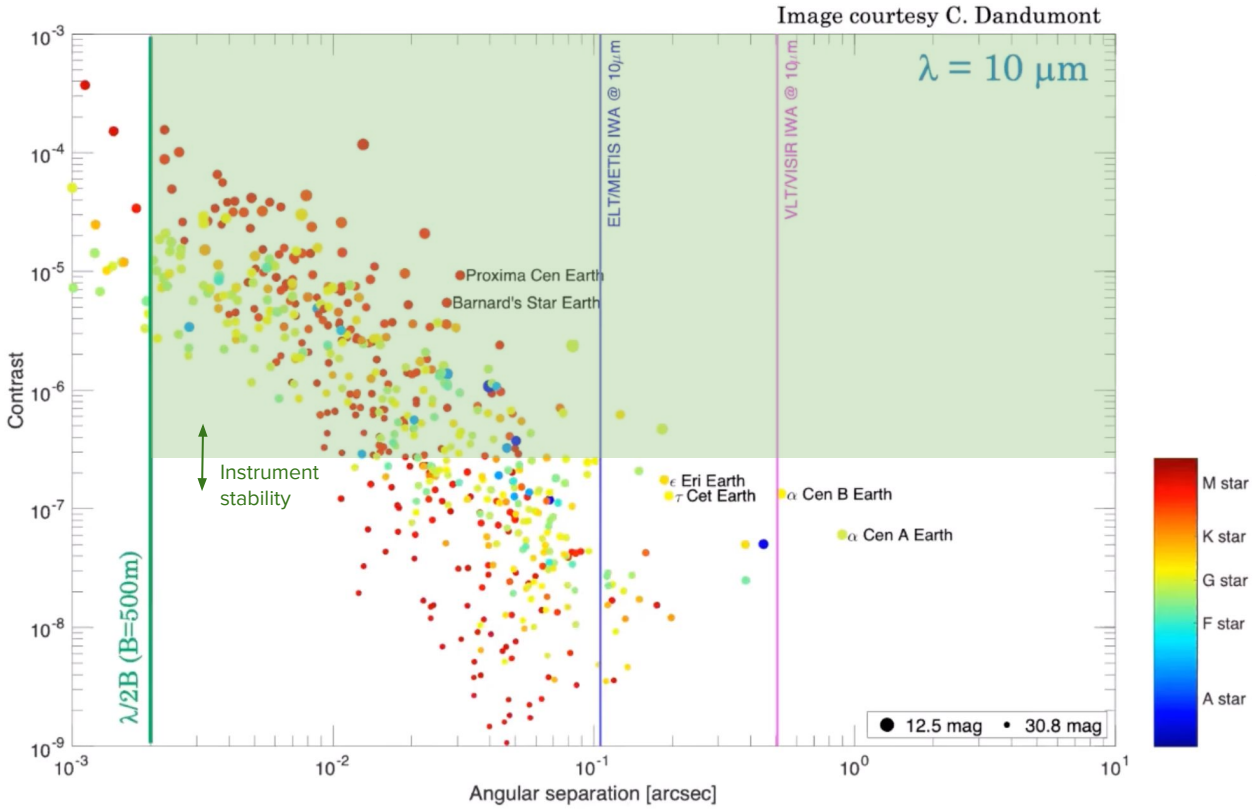
ESA announcement regarding Voyage 2050

“A large mission enabling the characterisation of the atmosphere of temperate exoplanets in the mid-infrared [...]”

“should be a top priority for ESA within the Voyage 2050 timeframe.”

Exoplanet population outlook



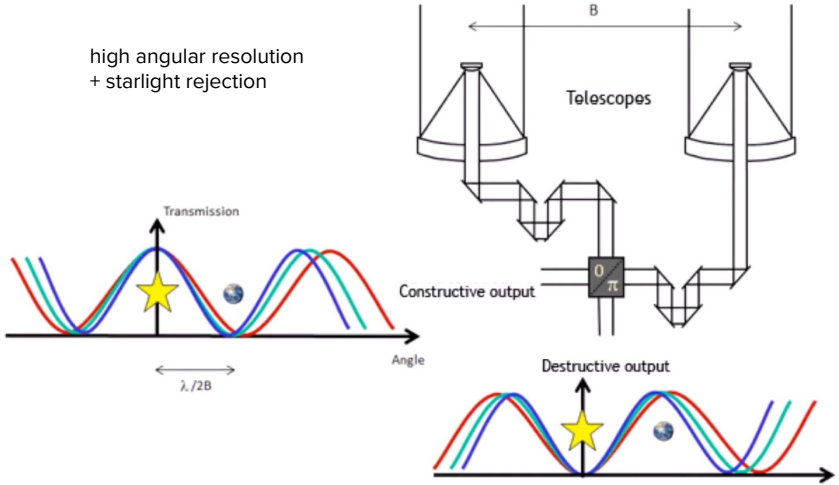


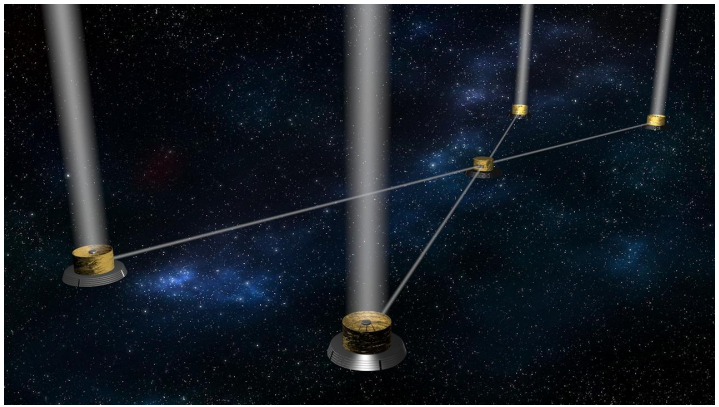
Angular resolution
Contrast
Sensitivity

Synthetic exoplanet population based on Kepler statistics (Kammerer & Quanz 2018)

LIFE measurement principle: nulling interferometry

high angular resolution
+ starlight rejection

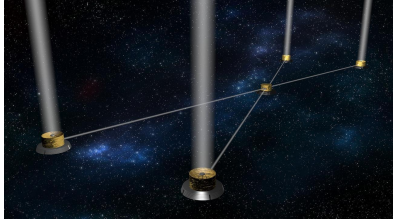




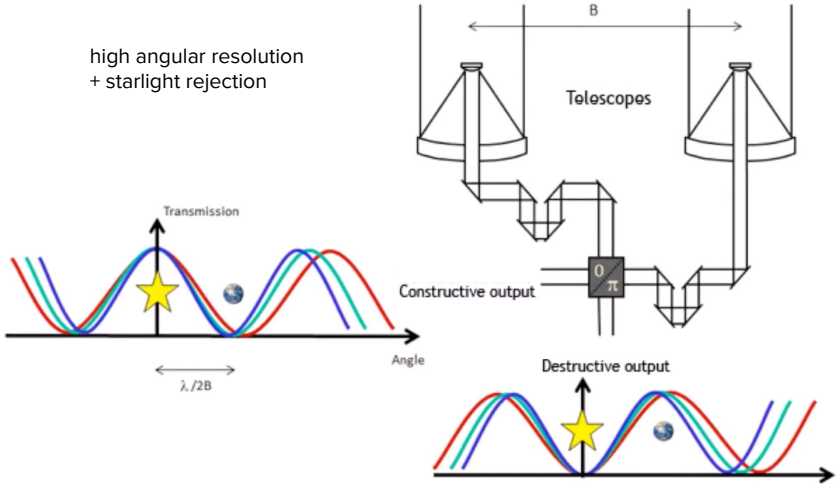
Bracewell 1978; image: O. Absil

Image: Denis Defrère

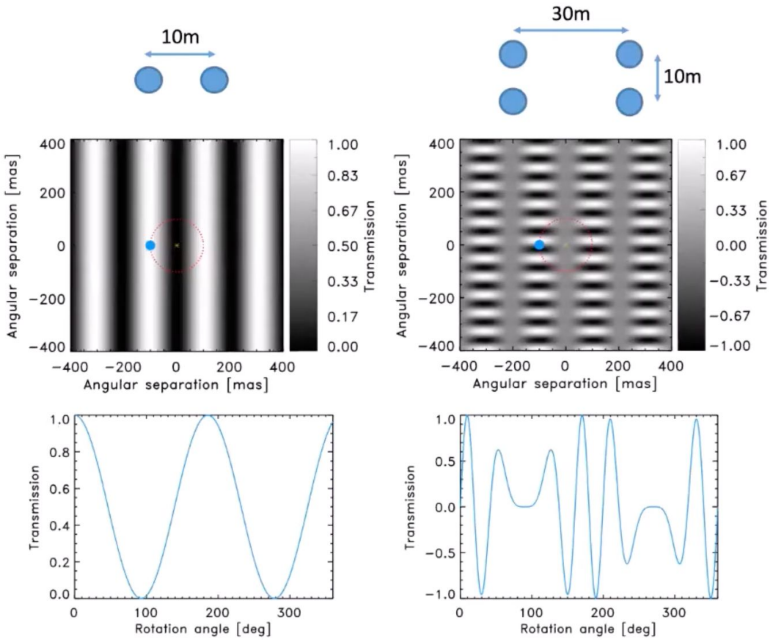
LIFE measurement principle: nulling interferometry



high angular resolution
+ starlight rejection



Transmission maps for 2 and 4 telescopes

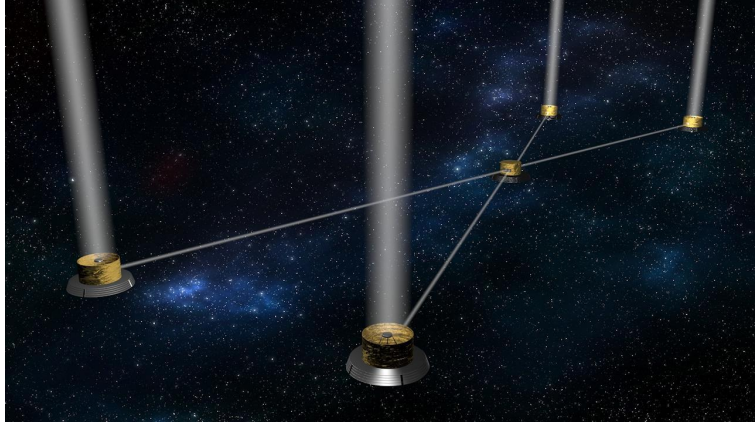


Earth-Sun system @ 10 pc + 10 µm

Bracewell 1978; image: O. Absil

Image: Denis Defrère

LIFE objectives



Obtain **thermal emission spectra** with sufficient spectral resolution, wavelength coverage and sensitivity to investigate **at least 30 (requirement) / 50 (goal) extrasolar planets** *with radii between 0.5 and 1.5 Earth radii and receiving between 0.35 and 1.7 times the insolation of the Earth* in order to **assess their diversity, habitability and search for biomarkers.** The sample shall be roughly equally split between late K to early M-type stars and late F to early K-type stars.

Nominal mission parameters

Number of collector spacecraft	4
Mirror diameter	2 m
Baseline length	10 – 600 m
Wavelength coverage	4 – 18.5 μm
Mission duration	2.5 yrs (search phase) 2.5 yrs (char. phase)

Sascha Quanz

Sarah Rugheimer

Daniel Angerhausen

Project Office Team
(led by PO Co-leads)

Science Team
(led by Science Co-leads)

Daniel Angerhausen

Lena Noack

Instrument Science Team
(led by Instrument Science co-leads)

Jens Kemmerer

Adrian Glauser

Technology Team
(led by Technology co-leads)

Hendrik Linz

Denis Defrere

LIFE initiative

+ many more

Join us:
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WG 3.2: LIFEsim

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WG 3.3: Signal processing

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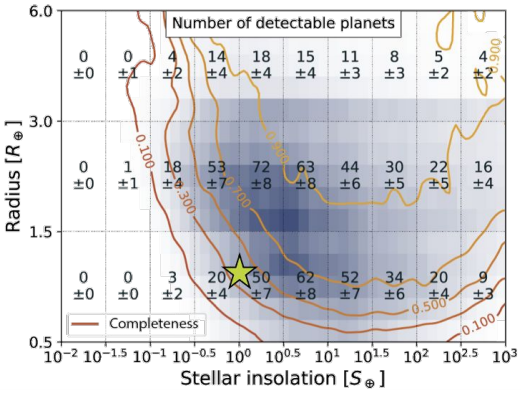
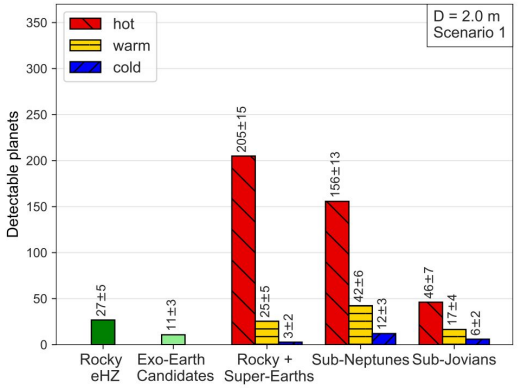
Exoplanet Yield Predictions

Instrument performance

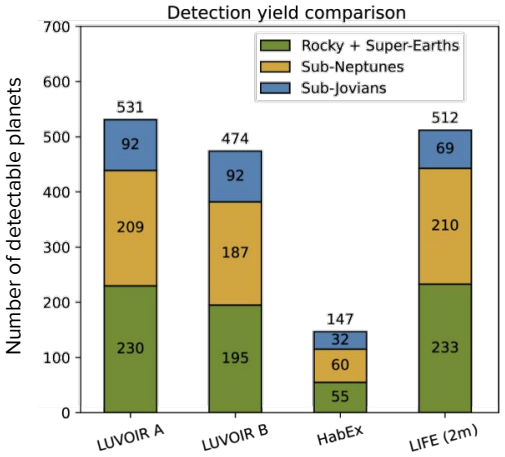


Felix Dannert, M.Sc. thesis

Exoplanet populations



Comparison



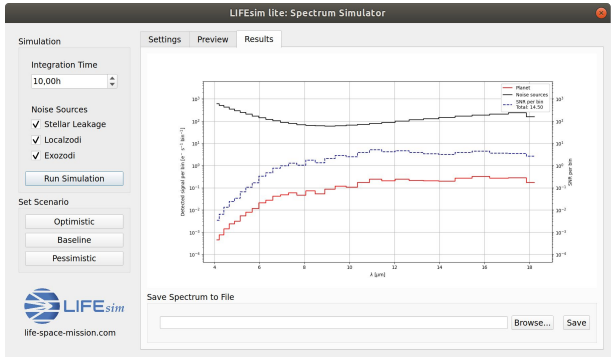
***LIFE I*: Quanz al. 2021, arXiv:2101.07500**

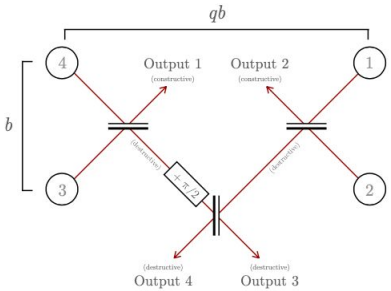
Simulator: *LIFEsim*

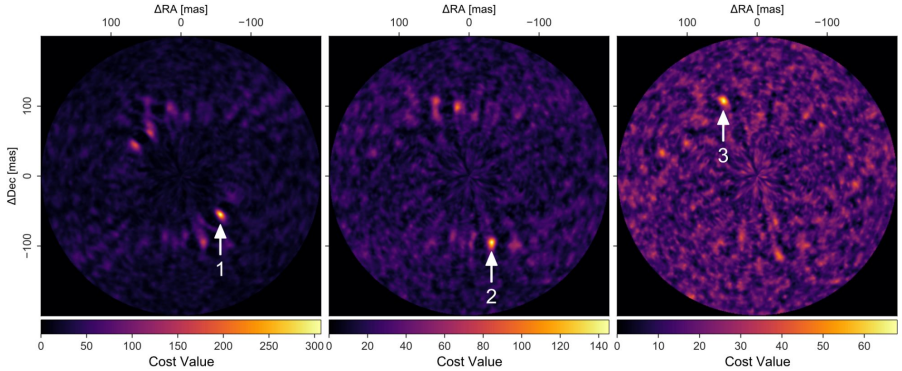
build to predict the mission yield and assign noise to spectra based on photon noise of relevant astrophysical noise sources

Pipeline:

- Generation of a synthetic planet population
- Astrophysical noise sources:
  - stellar leakage, exozodi, shot noise
- Planet detection
- Allocation of observing time



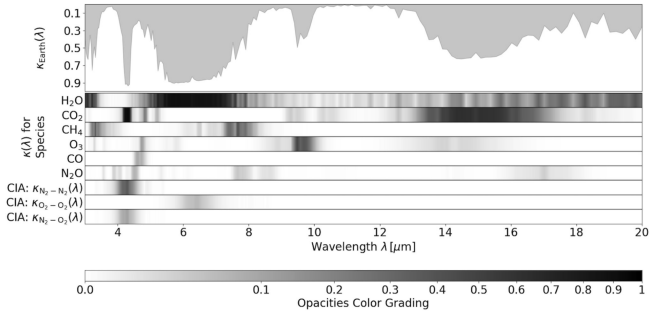


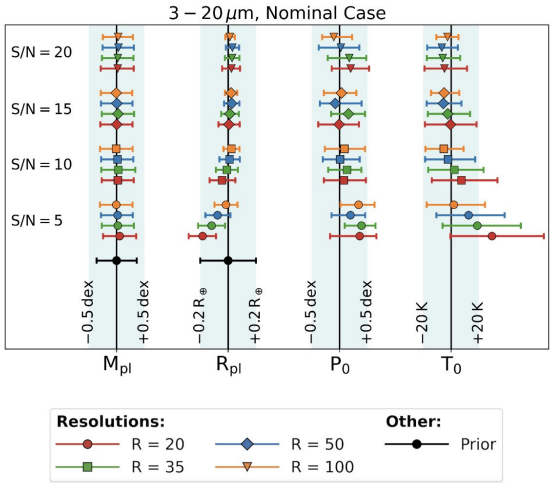


github.com/fdannert/LIFEsim

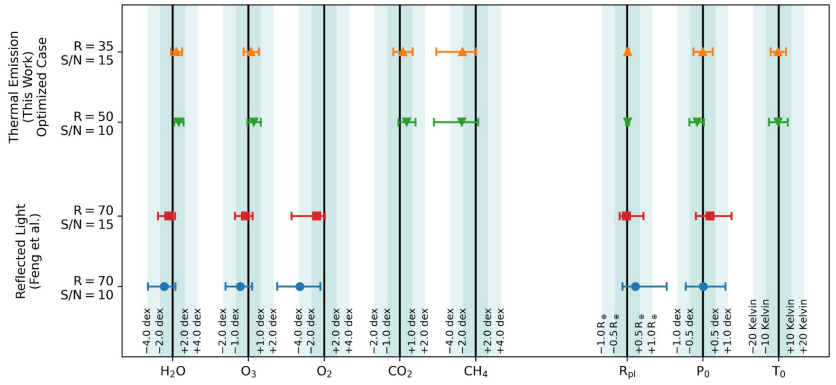
***LIFE II*: Ottiger et al. 2021, in rev.**

Earth-twin retrieval





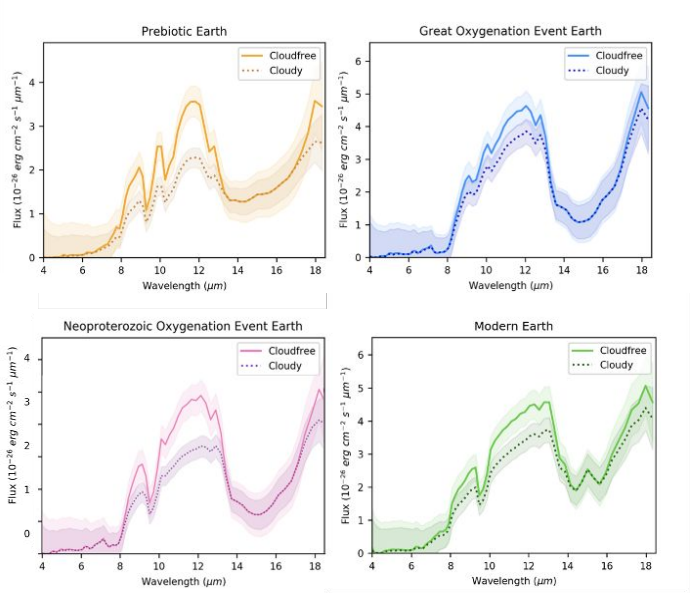
- H_2O, CO_2, O3 detectable for S/N ≥ 10
- CO, N_2, O_2 unconstrained
- CH_4 case-dependent
- R_{Pl} ± 10% , T_{surf} ± 20 K, P_{surf} ± 0.5 dex
- Min. requirements:
  - Wavelength coverage: 4–18.5 µm
  - Spectral resolution R = 50
  - S/N > 10
- For several exo-Earths at D = 10 pc:
  - Apertures ≥ 2 meters

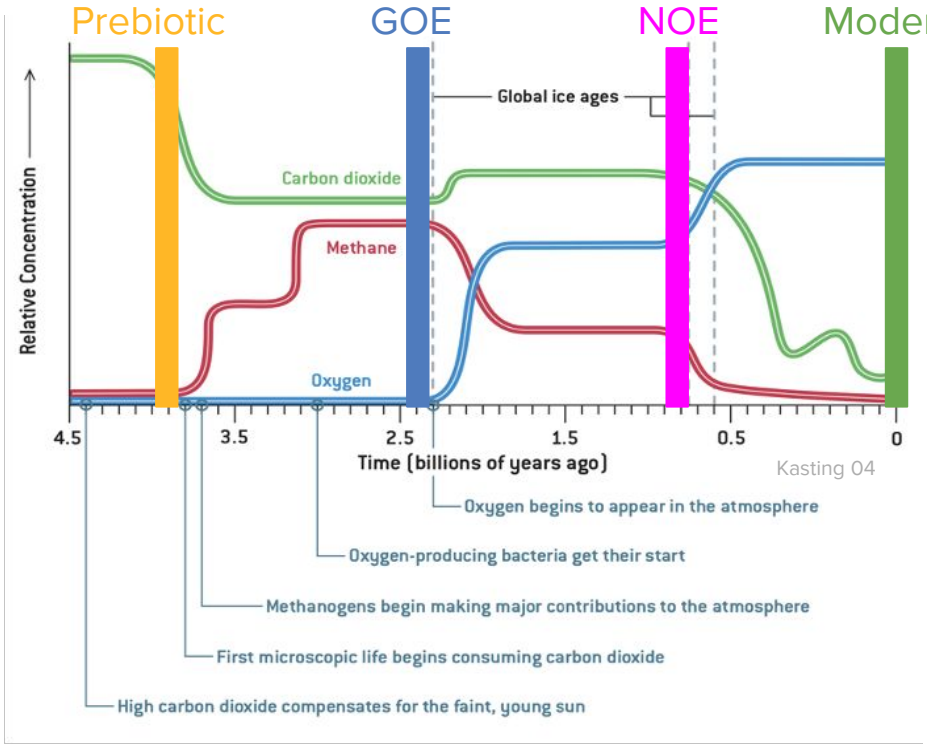


***LIFE III*: Konrad et al. 2021 (A&A, in press)**

“Earth in Time”

Could LIFE distinguish between **different eons of Earth**?





Species	Prebiotic	GOE	NOE	Modern
O_3	$\sim 10^{-11}$ ~	$\sim 10^{-8}$ ~	$\sim 10^{-7}$ ✓	$\sim 10^{-7}$ ✓
CH_4	$\sim 10^{-6}$ ~	$\sim 10^{-3}$ ✓	$\sim 10^{-4}$ ✓	$\sim 10^{-6}$ ~
H_2O	$\sim 10^{-3}$ ✓	$\sim 10^{-3}$ ~	$\sim 10^{-3}$ ~	$\sim 10^{-3}$ ✓

***LIFE IV*: Alei et al., in prep.**

LIFE wants you!

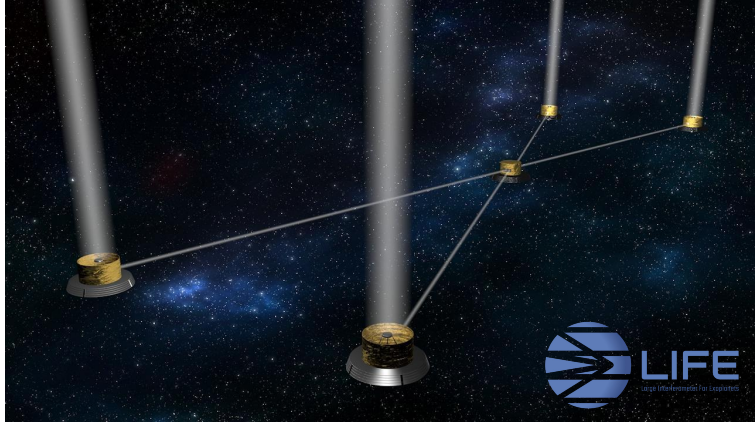
Webpage: **www.LIFE-space-mission.com**
Newsletter signup: **LIFE@phys.ethz.ch**

What you can do for us:

- Refer to LIFE as future platform in your papers
- Model future science cases:
  - Talk to us to simulate observations with LIFE
- **Become part of the LIFE team**

LIFE Annual Meeting 2021
8-10th November, fully virtual

Large Interferometer For Exoplanets



Quanz et al. 2019 (ESA WP)
https://arxiv.org/abs/1908.01316
Quanz et al. 2018 (SPIE)
https://arxiv.org/abs/1807.06088
Defrere et al. 2018 (ExAst)
https://arxiv.org/abs/1801.04150
Monnier et al. 2019 (Decadal WP)
https://arxiv.org/abs/1907.10663
Line et al. 2019 (Decadal WP)
https://ui.adsabs.harvard.edu/abs/2019BAAS...51c.271L/abstract
Quanz et al. 2021 (*LIFE I*)
https://arxiv.org/abs/2101.07500

In press/submission/preparation:
LIFE II: Ottiger et al. (LIFEsim)
LIFE III: Konrad et al. (exo-Earth)
LIFE IV: Alei et al. (Earth in time)
LIFE V: Angerhausen et al. (PH_3)
LIFE VI: Konrad et al. (exo-Venus)
LIFE VII+: Your paper?