EDEN
EXOEARTH DISCOVERY AND EXPLORATION NETWORK

@edensurvey

http://project-eden.space

THE SEARCH FOR NEARBY TRANSITING EARTHS

Università di Roma Tor Vergata

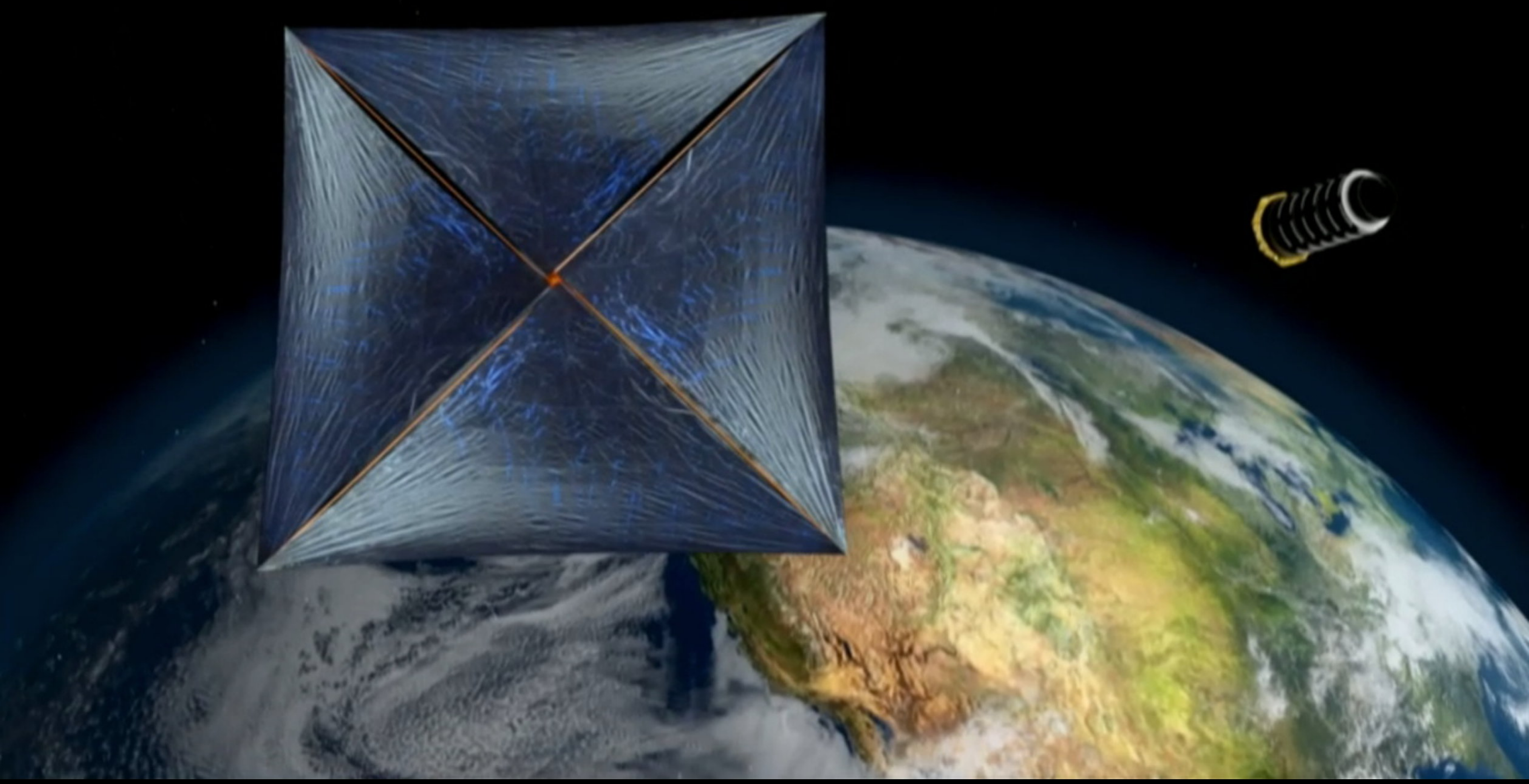
Luigi Mancini

Department of Physics, University of Rome Tor Vergata

@exoplanet_LM

We want to find Earth-like planets in the neighbors of the solar system, not only for the obvious observational reasons, but also in the spirit of future human exploration.

They will be the only planets that we can reach on a historical and non-geological time scale.



Nestor Espinoza
EDEN Expert

Bernoulli Postdoctoral Fellow at Max Planck Institute for Astronomy, Heidelberg. EDEN Photometry and Transit Forecast Teams.

Martin Schlecker
EDEN Graduate Student

Astronomy Graduate Student at the Max Planck Institute for Astronomy, Heidelberg. EDEN Observing Team and EDEN Targets Team

Marton Apai
EDEN Expert

Chief Technology Officer, IT Project Manager, Senior Software Engineer EDEN Software Development Expert

Luigi Mancini
EDEN Science Team

Senior Research Staff Scientist at the University of Rome Tor Vergata

Thomas K. Henning
EDEN Steering Committee

Director of the Planet and Star Formation Group at the Max Planck Institute for Astronomy, Heidelberg

Jose Perez Chavez
EDEN Undergraduate Student, Data Reduction Team

UA Astronomy/Astrobiology Undergraduate Student

Kerst Kingsbury
UA Undergraduate Student, EDEN Observations Team

University of Arizona Mining Engineering and Planetary Science undergraduate student

Allie Mousseau
EDEN Astronomy Student

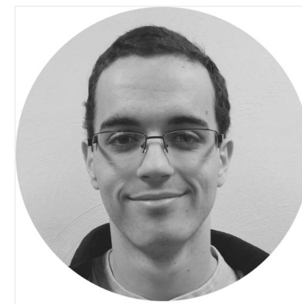
Astronomy student at The University of Arizona, and member of the EDEN Targets Team

Daniel Apai
EDEN Founder

Associate Professor of Astronomy and Planetary Sciences at The University of Arizona. Apai's blog (apai.space) covers news and thoughts related to exoplanet exploration and astrobiology.

Benjamin Rackham
EDEN Graduate Student

Astronomy graduate student at the Steward Observatory of The University of Arizona.



Alex Bixel
EDEN Graduate Student

Astronomy graduate student and NASA Earth and Space Science Fellow at the Steward Observatory of the University of Arizona.

Paul Gabor
Steering Committee member

Astronomer and Vice Directory of the Vatican Observatory Research Group.

EDEN Team

Steward Observatory, University of Arizona
Max Planck Institute for Astronomy, Heidelberg
University of Tor Vergata, Rome
NCU Taiwan

http://project-eden.space/team

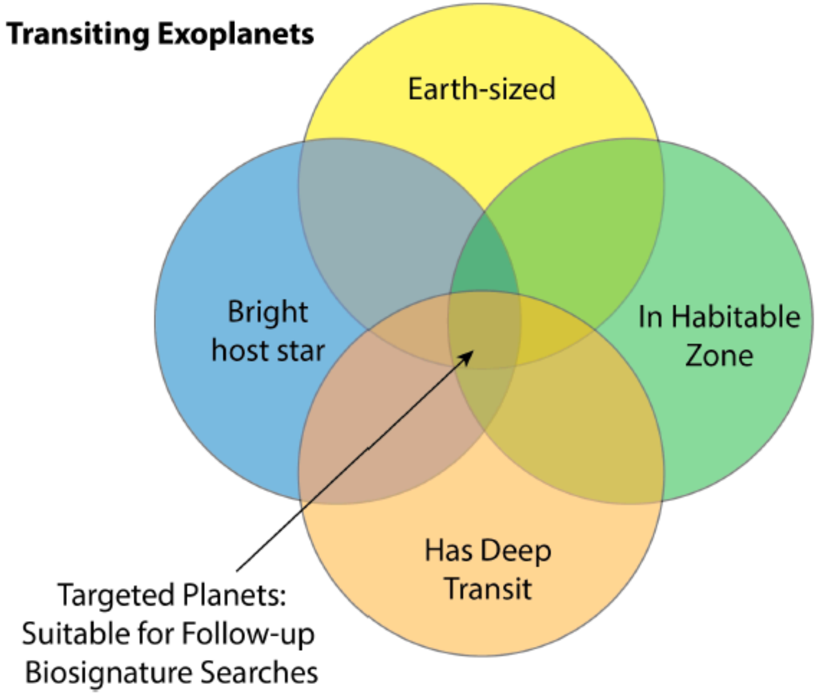
Are we looking for a needle in a haystack or is it just a sensitive problem?

- One of the most exciting forefronts of modern astrophysics is the study of Earth-sized planets, especially those in the habitable zones.

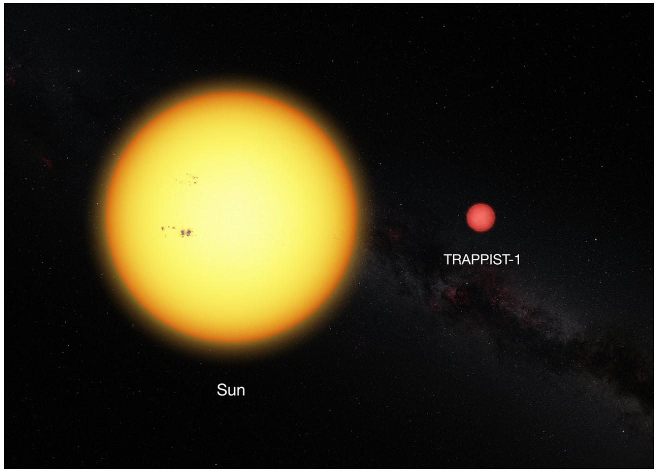
- We only know a handful of nearby systems with bright stars and transiting Earth-sized planets or transiting habitable zone non-Earth-sized planets; and only one system with relatively bright host star and deep transits of habitable zone Earth-sized planets: the TRAPPIST-1 system (**M8** star).

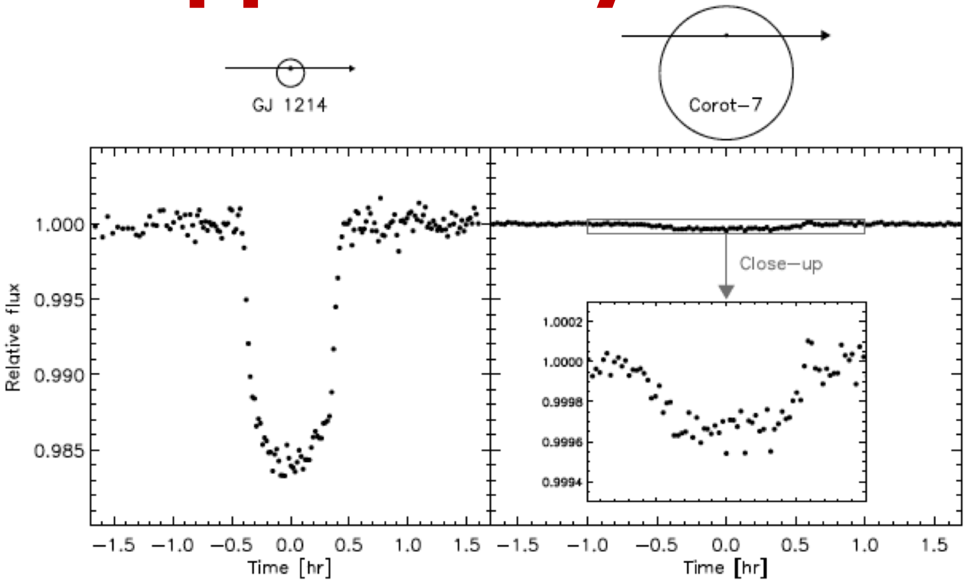
- Only 1 out of the approximately 2,800 planetary systems is suitable for follow-up spectroscopy to search for biosignatures.

- Most of the exoplanet searches are not sensitive to habitable zone Earth-sized planets.

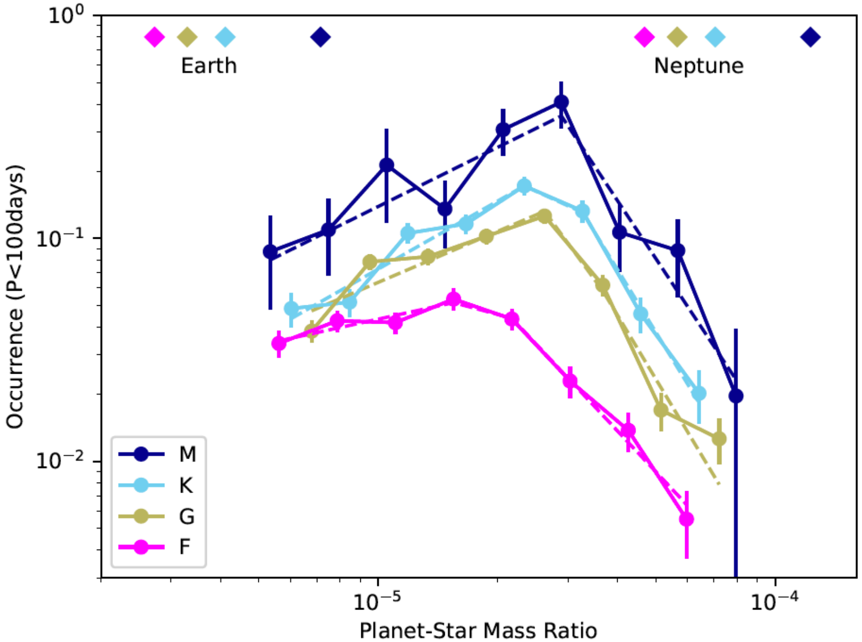


The Small Star Opportunity

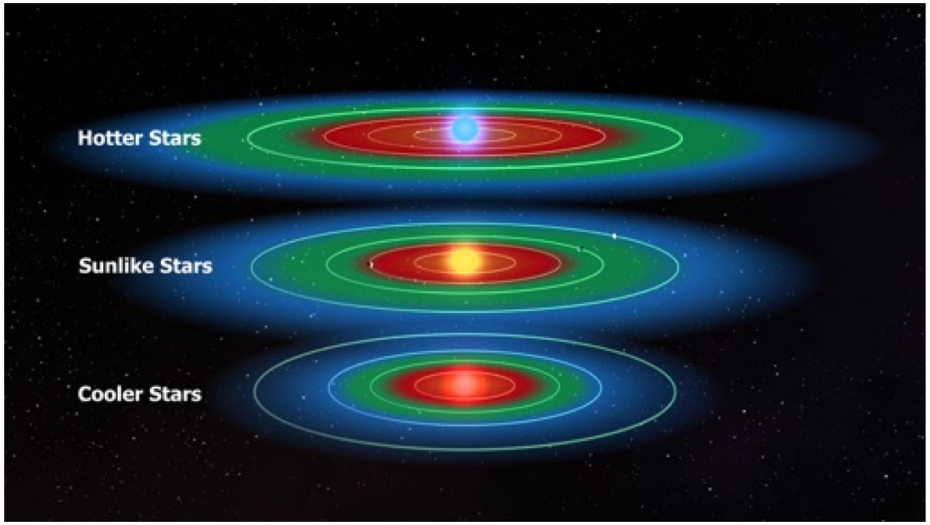




typical transit depth is 1%

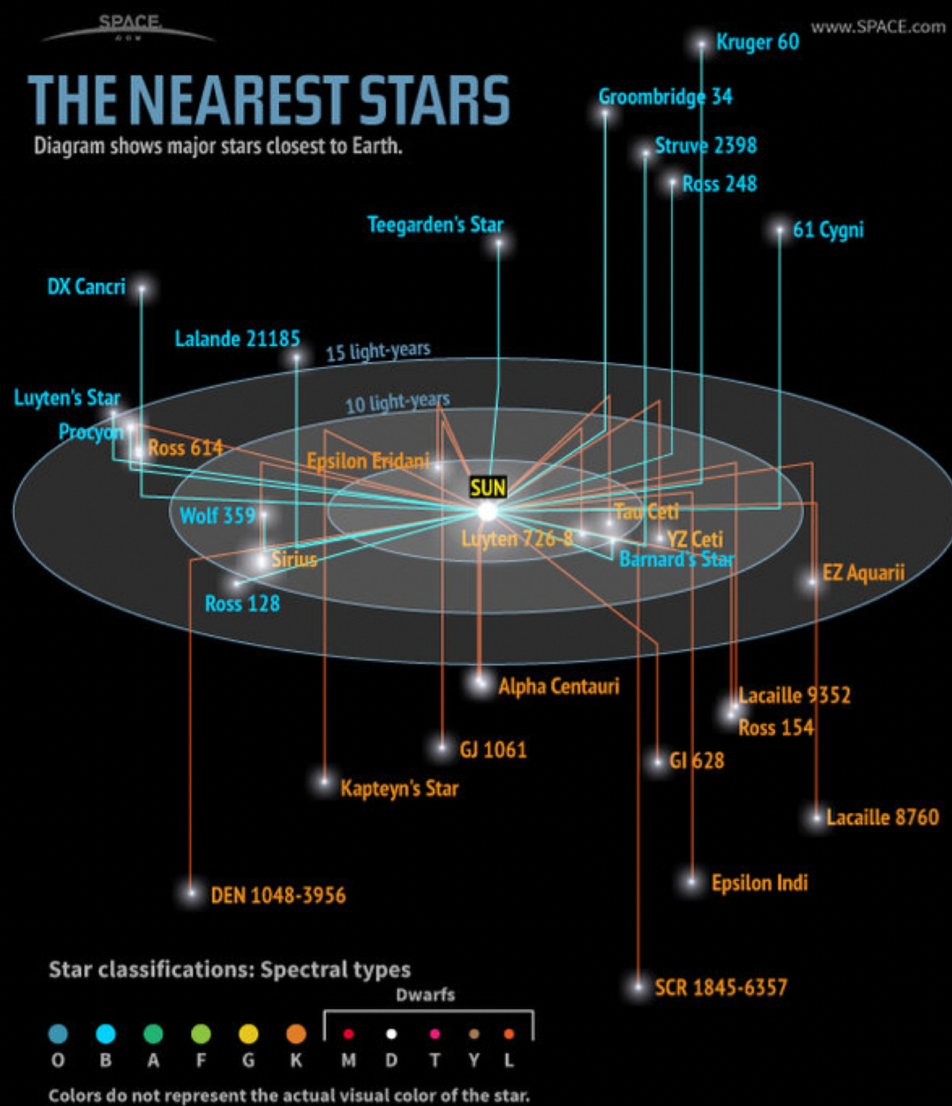


Pascussi et al., ApJ 856, 28 (2018)



Habitable zones lie closer to the parent stars

	Star system	Distance in light-years	Stellar type (s)	Observed planets
1	Alpha Centauri	4.24-4.37	M, G, K	1
2	Barnard's Star	5.96	M	1
3	Wolf 359	7.78	M	
4	Lalande 21185	8.29	M	
5	Sirius	8.58	A, D	
6	Luyten 726-8	8.73	M, M	
7	Ross 154	9.68	M	
8	Ross 248	10.32	M	
9	Epsilon Eridani	10.52	K	2
10	Lacaille 9352	10.74	M	
11	Ross 128	10.92	M	
12	EZ Aquarii	11.27	M, M, M	
13	Procyon	11.40	F, D	
14	61 Cygni	11.40	K, K	
15	Struve 2398	11.53	M, M	
16	Groombridge 34	11.62	M, M	
17	Epsilon Indi	11.82	K, T, T	
18	DX Cancri	11.83	M	
19	Tau Ceti	11.89	G	5
20	GJ 1061	11.99	M	
21	YZ Ceti	12.13	M	
22	Luyten's Star	12.37	M	
23	Teegarden's Star	12.51	M	
24	SCR 1845-6357	12.57	M, T	
25	Kapteyn's Star	12.78	M	
26	Lacaille 8760	12.87	M	
27	Kruger 60	13.15	M, M	
28	DEN 1048-3956	13.17	M	
29	UGPS 0722-05	13.26	T	
30	Ross 614	13.35	M, M	
31	WISE 1541-2250	13.70	Y	
32	WISE 0350-5658	13.70	Y	
33	Wolf 1061	13.82	M	
34	Van Maanen's Star	14.07	D	
35	Gliese 1	14.23	M	
36	Wolf 424	14.31	M, M	
37	TZ Arietis	14.51	M	
38	Gliese 687	14.80	M	
39	LHS 292	14.80	M	
40	Gliese 674	14.81	M	1
41	GJ 1245	14.81	M, M, M	
42	Gliese 440	15.06	D	
43	GJ 1002	15.31	M	
44	Gliese 876	15.34	M	4
45	LHS 288	15.61	M	
46	WISE 1405+5534	15.76	Y	
47	Gliese 412	15.83	M, M	
48	Groombridge 1618	15.85	K	
49	AD Leonis	15.94	M	
50	DENIS J081730.0-615520	16.07	T	
51	Gliese 832	16.08	M	1
52	LP 944-020	16.19	M	
53	DEN 0255-4700	16.20	L	



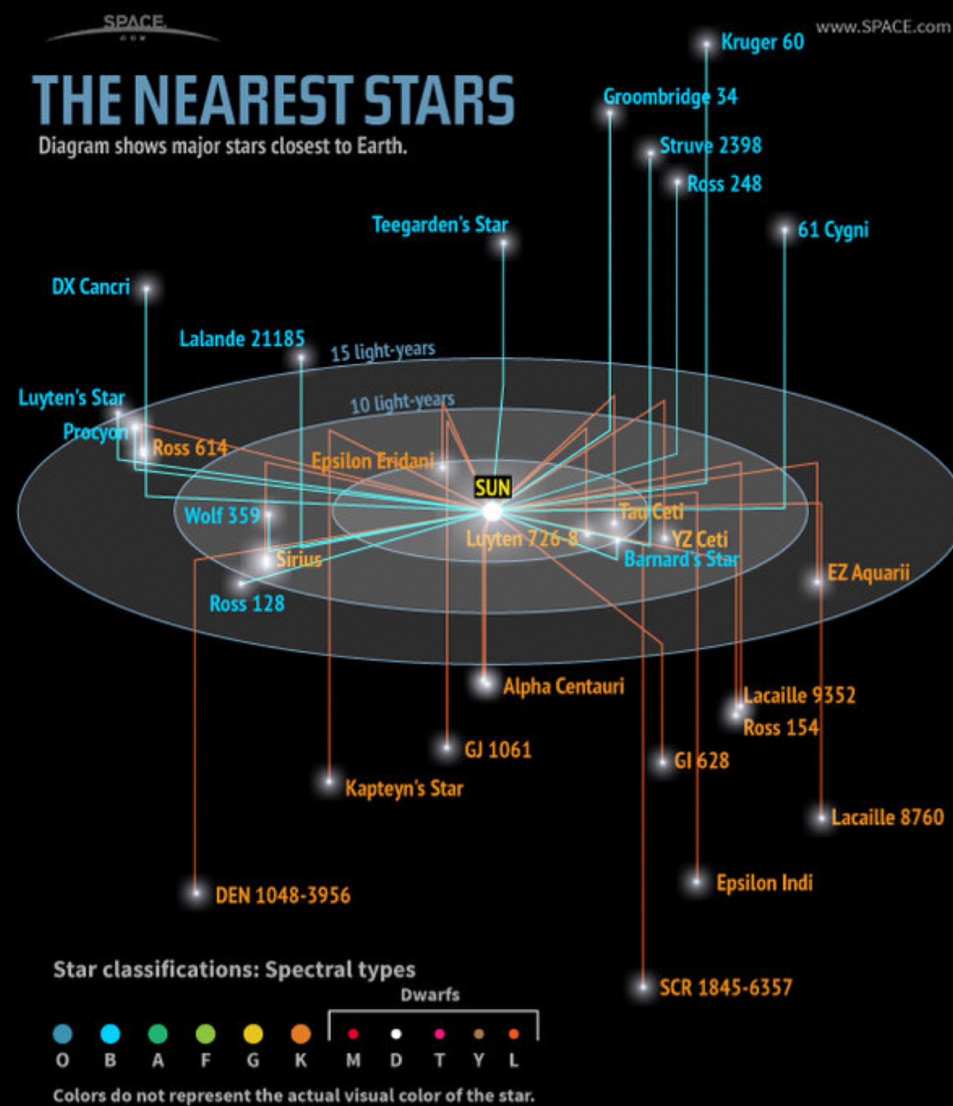
Predicted Census Within 50 Lightyears

- Stars: ≈ 1,560
- Exoplanets: ≈ 10,0000
- Temperate zone
  earth-sized planets: ≈ 1,000

(based on *Kepler* statistics for low-mass stars)

Discovered – as of now:

- Exoplanets: 104
- Approx. Earth-sized: 9
- Temperate zone
  earth-sized planets: 3 - 4

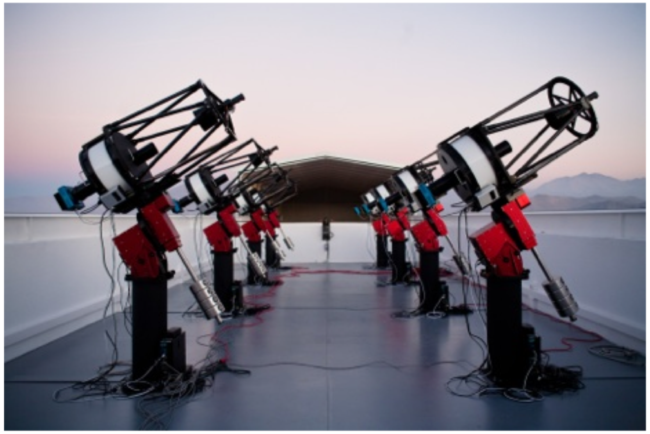


Ongoing Planet Surveys

- The existing operational telescopes are limited to diameters in the 0.4-0.6m range (MEARTH, APACHE), with the first dedicated 1m telescopes (SPECULOOS) have just become operational in the southern hemisphere.

- Stars cooler than M5 have never been searched systematically for Earth-sized transiting planets on the northern sky and, for the next year, there will be no facility efficiently surveying them.

MEARTH (Charbonneau et al.)



SPECULOOS (Gillon et al.)

APACHE (Sozzetti et al.)

EDEN

Exoearth Discovery and Exploration Network

- To find and characterize habitable worlds within 50 lightyears from the northern hemisphepre.

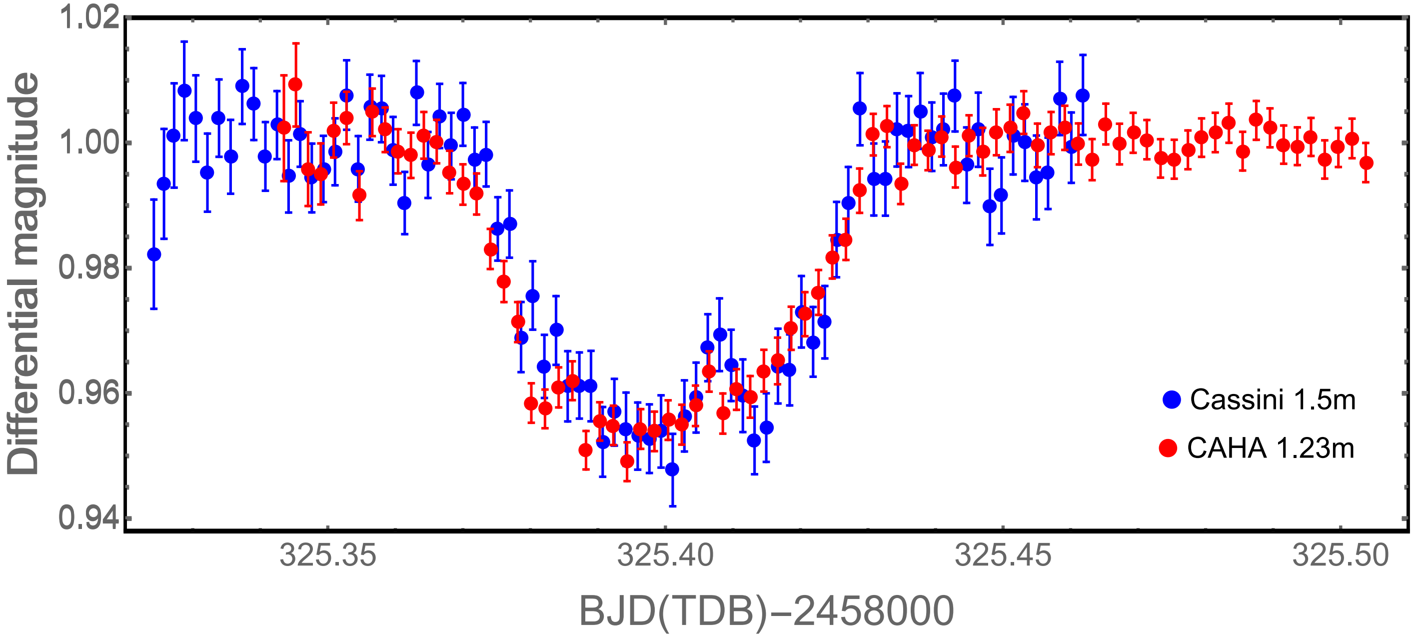
- Survey mid- to late-M type stars for habitable-zone Earth-sized planets with a network of medium-sized (1m-class) telescopes.

- The estimate is 1 new system for each ≈ 100 nights worth of good data.
- Non-detections will also be useful to constrain the possible existence of transiting planets (as we cover significant fraction of the HZ orbital periods).

CAHA 1.2m

Cassini 1.5m

WTS-2b (V=15.9 mag)



EDEN Status

Pilot Survey

complete and successful

Main Survey

began in Summer 2018, full operations since Fall 2018

End-to-end functionality

(Working versions of target catalog, observing procedures, data catalog, automated photometric pipeline, transit detection algorithms, trend analysis, transit fitting, data visualization, etc.)

TESS folow-up capability

We will follow up several dozens TESS candidates, once the northern candidates start to come out in large numbers (all current candidates have been too southern for EDEN)

Website, Twitter feed, Newsletter

All functional

EDEN Status

Data reduction

We are using two photometric pipelines for the photometry and reference-star based correction, developed by members of our team.

Light-curve analysis (de-trending and transit search)

We have three approaches:

- a decomposition into independent processes;
- a general Fourier-based trend modeling followed by a BLS search;
- a Gaussian Processes-based approach.

EDEN Status

For now, we have focused on 4 objects and will move on to next ones in December/January.

Summary of the # of hours on our targets so far

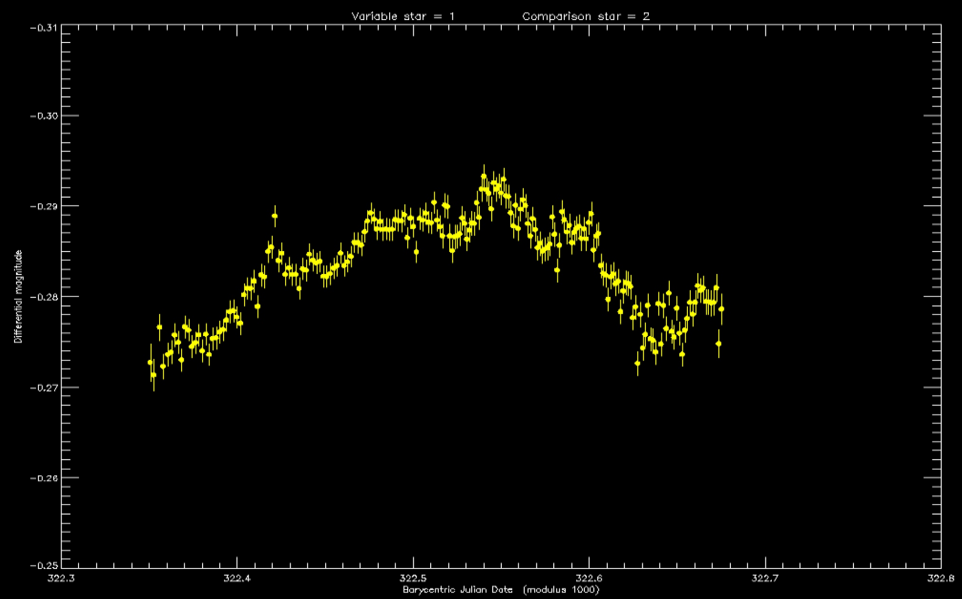
Cassini: 39 hours

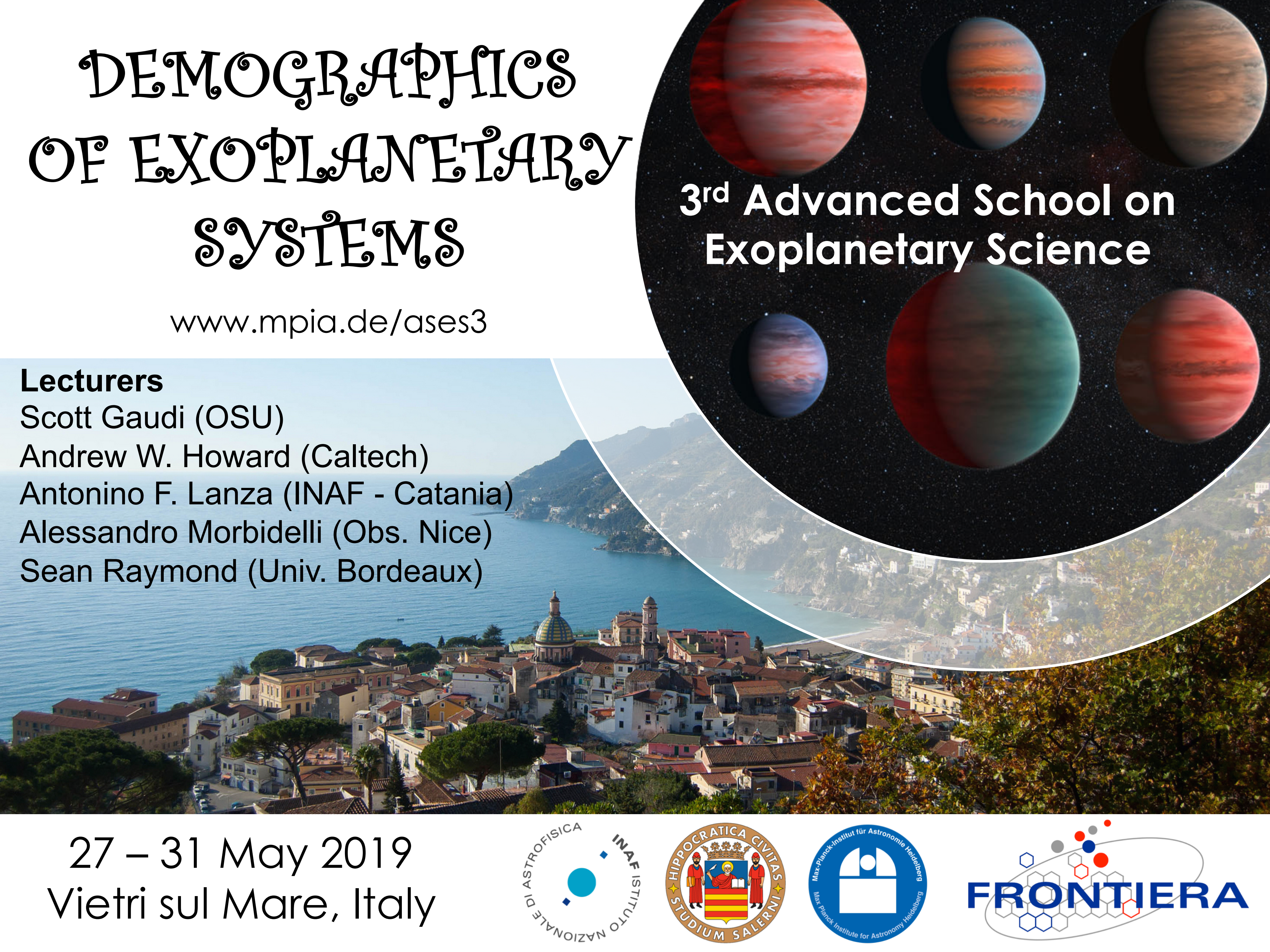
Kuiper: 118 hours

Schulman: 120 hours

Calar Alto: 158 hours

VATT: 24 hours




DEMOGRAPHICS OF EXOPLANETARY SYSTEMS
3rd Advanced School on Exoplanetary Science
www.mpia.de/ases3
Lecturers
Scott Gaudi (OSU)
Andrew W. Howard (Caltech)
Antonino F. Lanza (INAF - Catania)
Alessandro Morbidelli (Obs. Nice)
Sean Raymond (Univ. Bordeaux)
27 – 31 May 2019
Vietri sul Mare, Italy
INAF ISTITUTO NAZIONALE DI ASTROFISICA
HIPPOCRATICA CIVITAS STUDIUM SALERNI
Max-Planck-Institut für Astronomie Heidelberg
Max Planck Institute for Astronomy Heidelberg
FRONTIERA