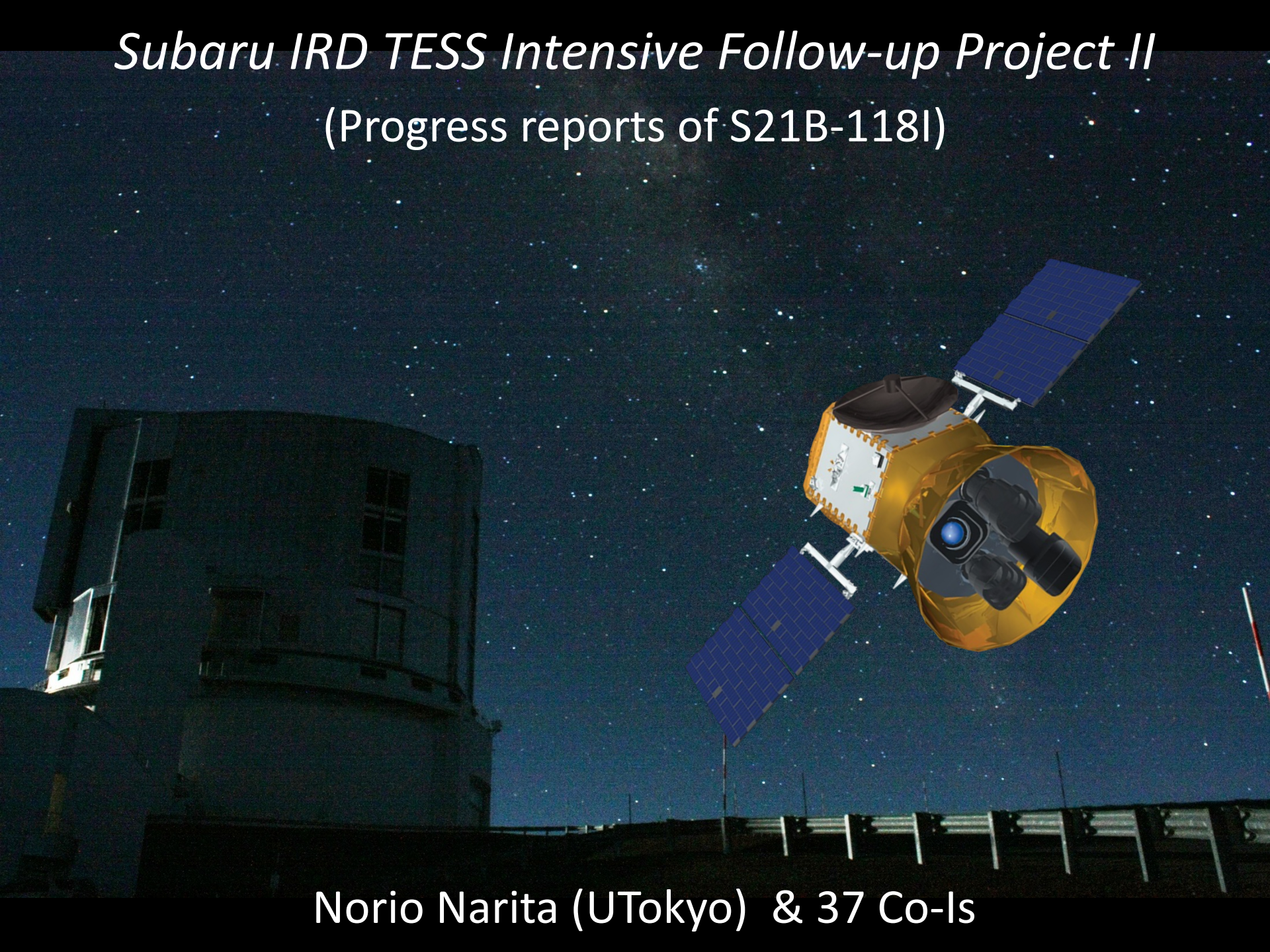
Subaru IRD TESS Intensive Follow-up Project II

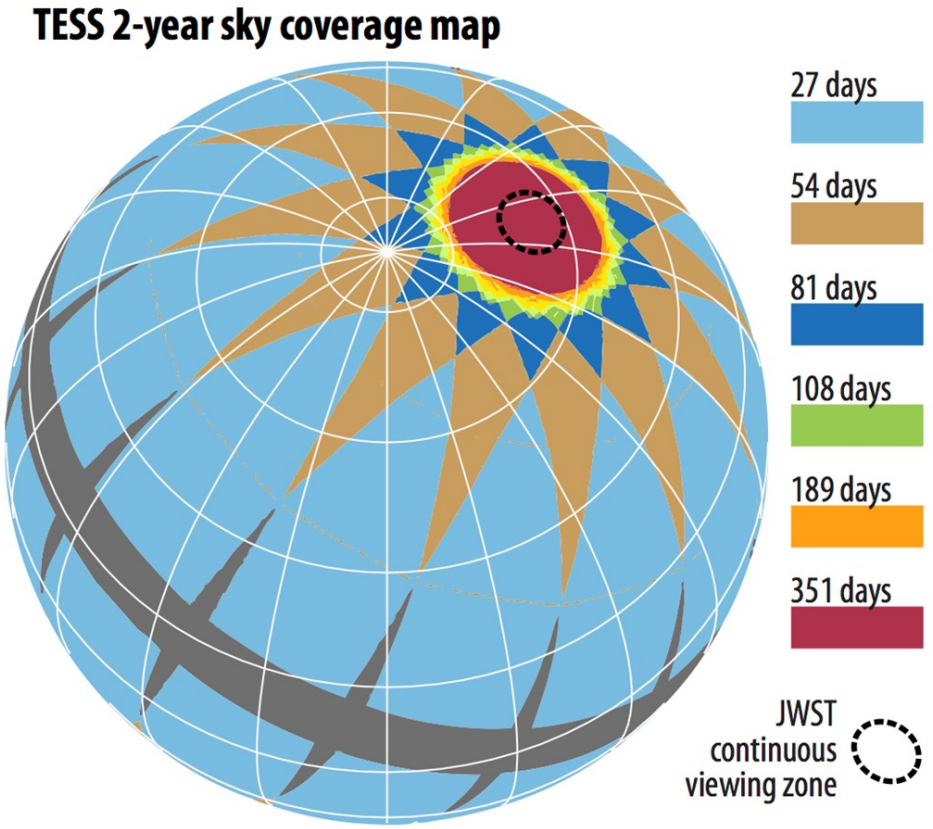
(Progress reports of S21B-118I)



Norio Narita (UTokyo) & 37 Co-Is

TESS Introduction

Launched on April 18, 2018

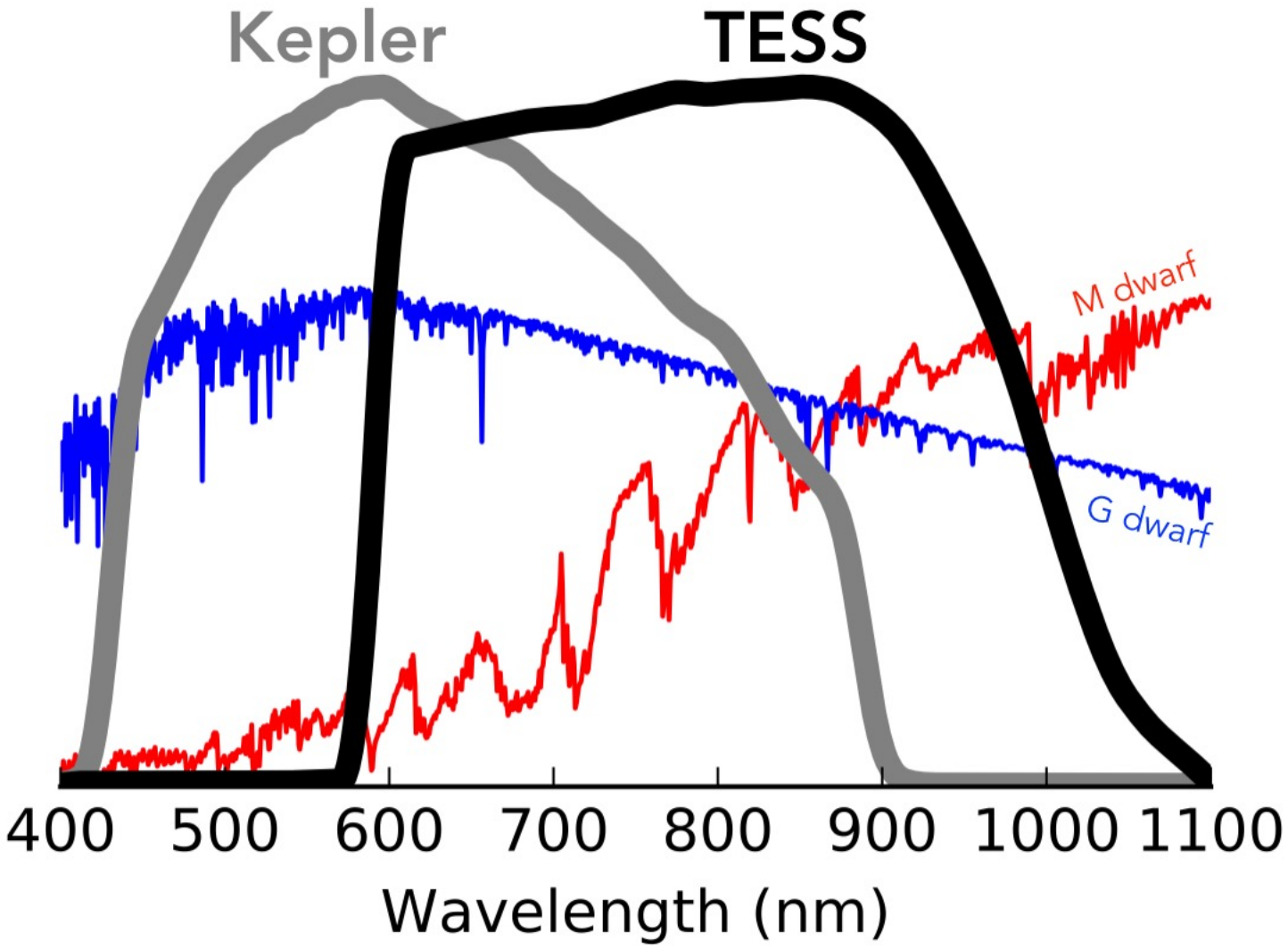


Observing 24 deg x 96 deg FoV ("sector") at a time for 27.4 days

TESS completed the primary mission (2018-2020 July) and

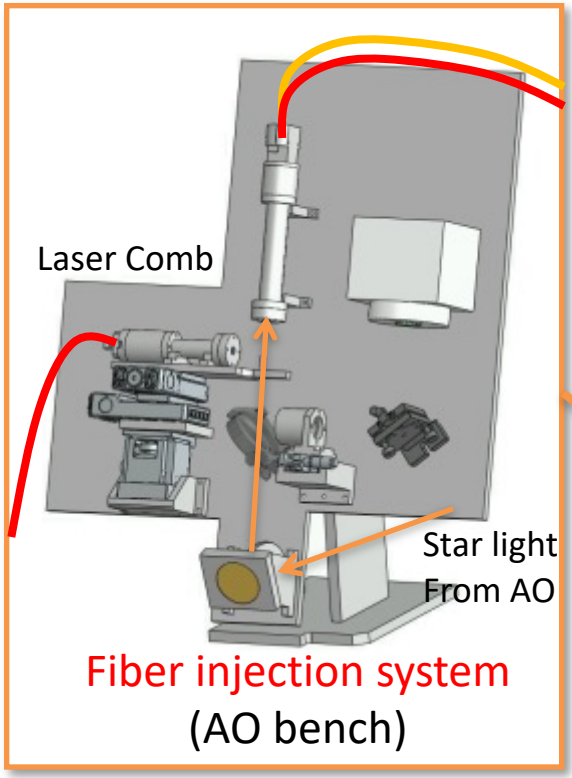
currently the 2nd extended mission (ETM2) is ongoing (2022-2025)

Comparison of TESS and Kepler bandpass

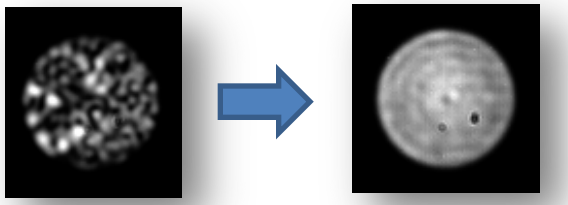


TESS is more favorable for nearby M dwarfs than Kepler

Overview of the IRD instrument

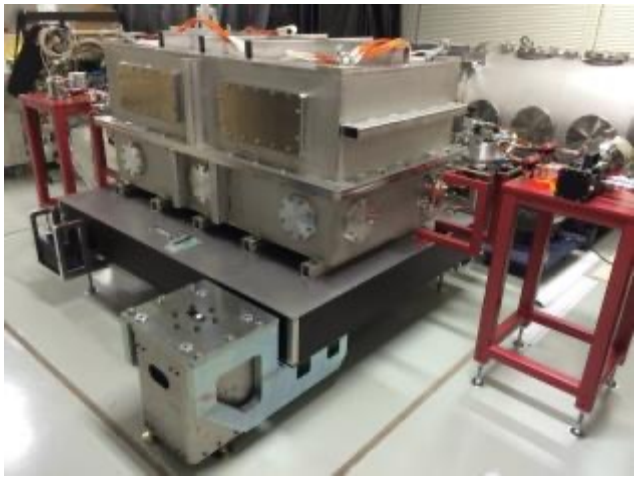


Fiber injection system
(AO bench)

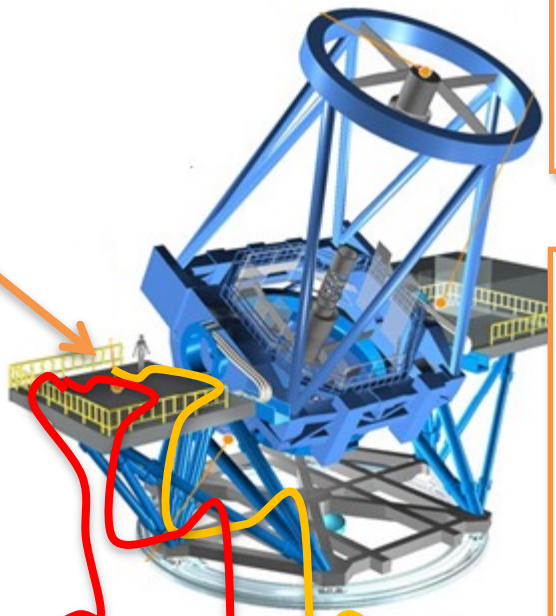


Mode scrambler

Resolution: R=70000
Wavelength: 0.97-1.75um
Cryo: 60K (detector), 200K (optics)



Spectrometer system
(Coudé room)

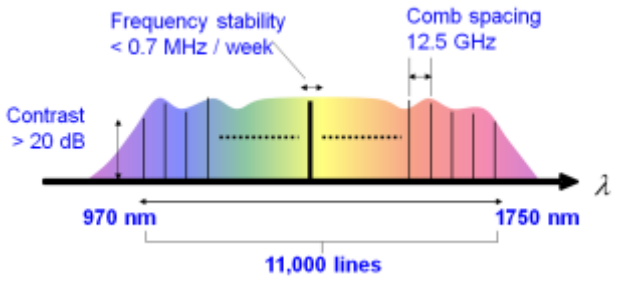


Fiber
(Comb)

Fiber
(star)

spectrometer

Coudé Room

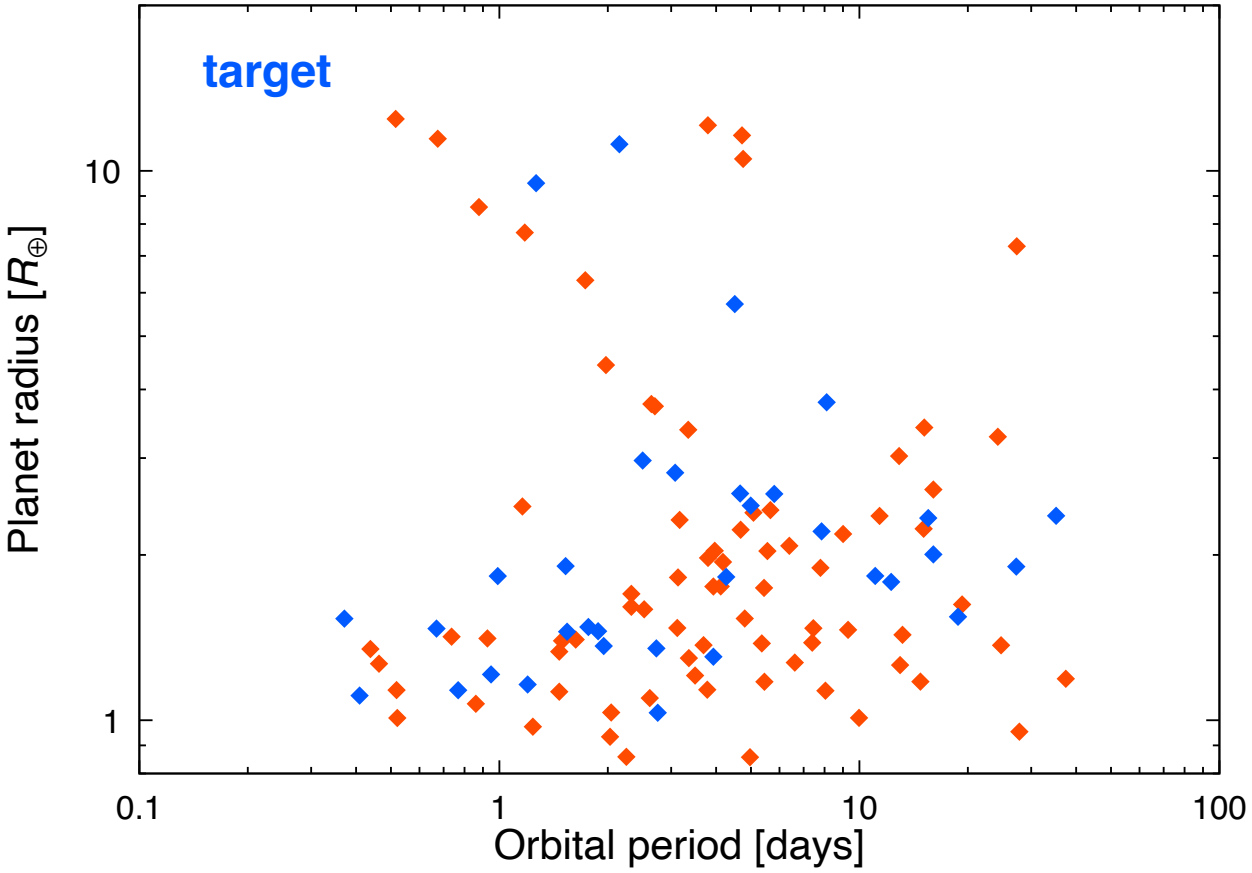


Laser frequency comb
(IR Observing floor)

TESS candidate planets (TOIs) around stars T_{eff} < 3500K

TESS has discovered 100+ TOIs as of April 2021

50+ TOIs are observable from Maunakea with >40 deg elevation



We have selected ~30 TOIs to characterize

the masses, orbits, and atmospheres with Subaru IRD

Numbers of allocated nights and success rate (19A-21A)

S19A-069I (3 semesters x 3 nights + 1 compensation night)

- 19A: 3 nights -> 1.5 successful nights (1.5 night lost due to weather)
- 19B: 3 nights -> 1 successful night (2 nights lost due to weather)
- 20A: 3 nights -> 0 night (all nights lost due to weather and COVID)
- 20B: +1 night -> 1 successful night (compensation for COVID)

S20A-103N (4 nights, thanks to the special rule)

- 20A: 4 nights -> 0 night (all nights lost due to weather and COVID)

S20B-088I (2 semesters x 7 nights, although requested 6 semesters)

- 20B: 7 nights -> 5 successful nights (2 nights lost due to weather)
- 21A: 7 nights -> 2.5 successful nights (4.5 nights lost due to weather and telescope trouble)

- 11 successful nights in total / 28 allocated nights (39% success, 19A-21A)

Numbers of allocated nights and success rate (21B-22B)

S21B-118I (3 semesters x 10 nights)

- 21B: 11 nights -> 5 successful nights
- 22A: 3 IRD + 3.5 MAROON-X nights -> 1 + 3.5 successful nights
- 22B: 11.5 IRD + 1 MAROON-X nights -> 3 + 1 successful nights

- Success rate (IRD): 9/25.5 = 35%
- Success rate (MAROON-X): 4.5/4.5 = 100%
- Success rate of 21B-118I: 13.5/30 = 45%

- Success rate (19A-22B in total): 24.5/58 = 42%

Publications using the IRD intensive data

Published papers (reported in Subaru UM FY2021)

1. TOI562 (Ruque+ 2019): validation
2. TOI736 (Crossfield+ 2019): validation
3. TOI2221=AU Mic (Hirano+ 2020): spin-orbit alignment, press release
4. TOI488 (Kemmer+ 2020): mass determination / additional planet
5. TOI732 (Nowak+ 2020): mass determination
6. TOI1640 (Soto+ 2021): mass determination
7. TOI1634 & 1685 (Hirano+ 2021): mass determination, press release
8. TOI2221=AU Mic (Cale+ 2021): mass determination
9. TOI2285 (Fukui+ 2022): validation, press release

Publications using the IRD intensive data

Published/accepted papers (after Subaru UM FY2021)

10. TOI1696 (Mori+ 2022）: validation, sub-Neptune
11. TOI1452 (Cadieux+ 2022): validation, temperate sub-Neptune
12. TOI2136 (Kawauchi+ 2022): validation, helium search, sub-Neptune
13. TOI4306 (Delrez+ 2022): validation, habitable super-Earth, press release
14. TOI5557 (Hirano+ 2023): validation, Earth-sized planet, also observed in openuse&SSP

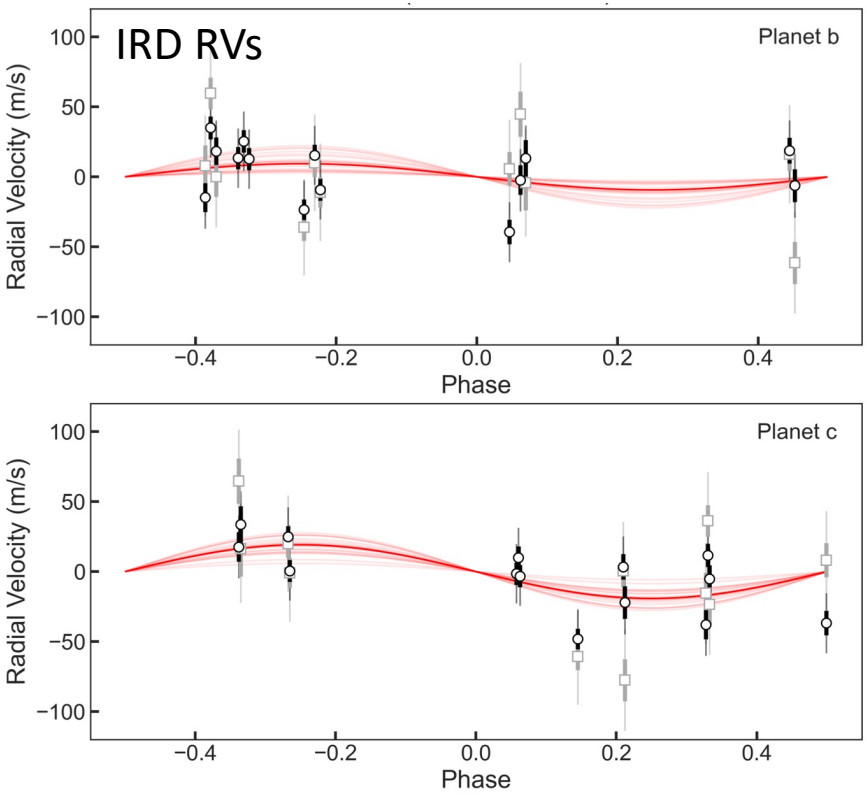
Submitted papers (after Subaru UM FY2021)

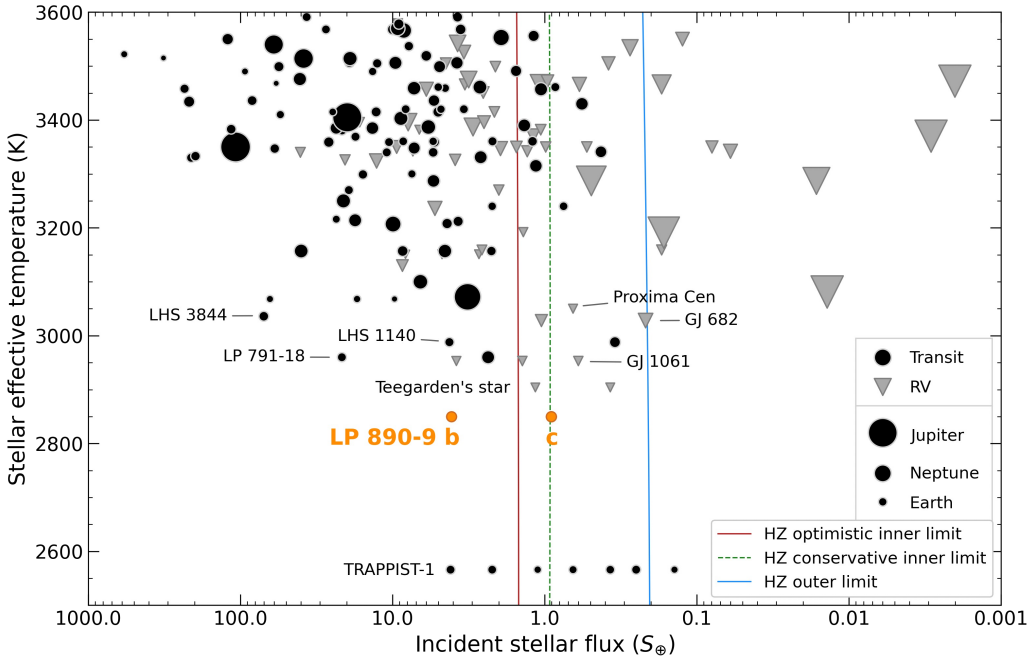
15. TOI1442,2445 (Morello+ submitted): validation, ultra-short period planets
16. TOI519 (Kagetani+ submitted): mass determination, giant planet

Discovery of a super-Earth in the habitable zone

We validated two super-Earths around an M6 dwarf

LP 890-9 (TOI-4306, SPECULOOS-2) at 32 pc



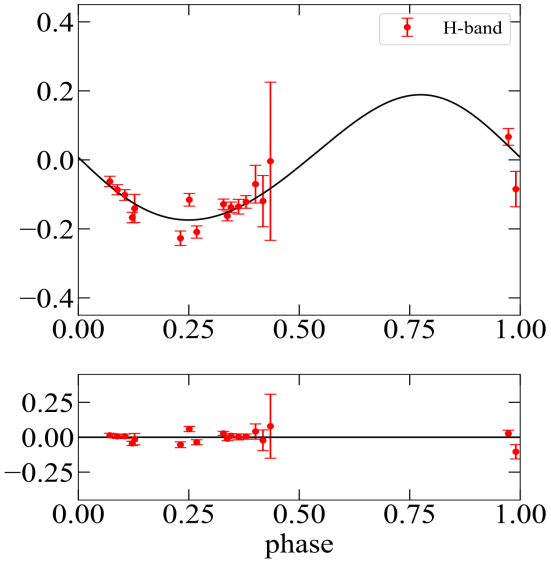


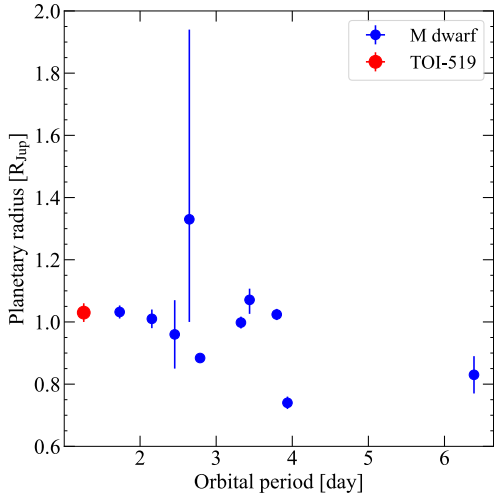
The outer one is a 1.37 R_{Earth} planet in the habitable zone

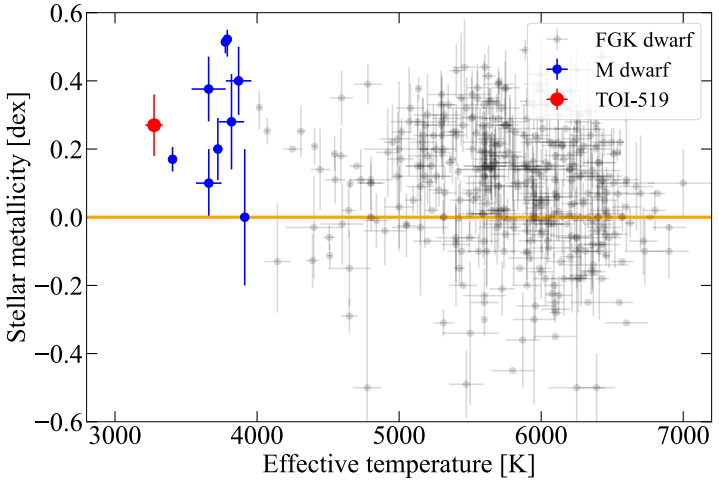
Delrez, Murray, Pozuelos, Narita et al. (2022), PR on 2022/9/7

A close-in giant planet around a mid-M dwarf

We have identified that TOI-519 b is a giant planet, not a brown dwarf







$M_p = 0.463^{+0.082}_{-0.088}\ M_{\rm Jup}$

$R_p = 1.03 \pm 0.03\ R_{\rm Jup}$

$P = 1.265$ days

$[{\rm Fe/H}] = 0.27 \pm 0.09$

$T_{\rm eff} = 3275 \pm 61$ K

TOI-519 b is the shortest-period giant planet

around the lowest temperature M dwarf known so far

Kagetani et al. submitted (Details will be presented by Taiki Kagetani tomorrow)

What we have achieved

- We have discovered (either constrained or determined masses of) 22 planets in 16 planetary systems using the IRD intensive data
  - 11 likely Earth-like planets, including one in the habitable zone
    - TOI562b, TOI736b, TOI488b, TOI732b, TOI1442b, TOI1634b, TOI1685b, TOI2445b, TOI4306b&c, TOI5557b
    - contributing to one of the Science Goals of Subaru Telescope 2.0
  - several sub-Neptunes (favorable for future atmospheric characterization with JWST, Ariel)
  - one close-in giant planet around a mid-M dwarf, which was thought to be very rare (high impact on planet formation models)
- We have also identified several planetary systems with additional outer planets
  - also important for planet formation models