Search for Planets like Earth around Late-M Dwarfs: Precise Radial Velocity Survey with IRD

PI: Bun′ei Sato (Tokyo Institute of Technology)
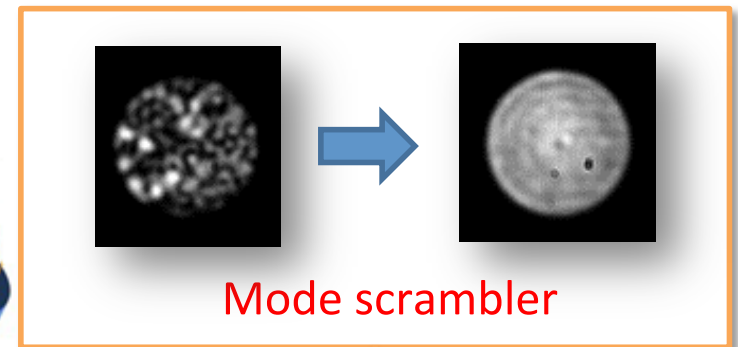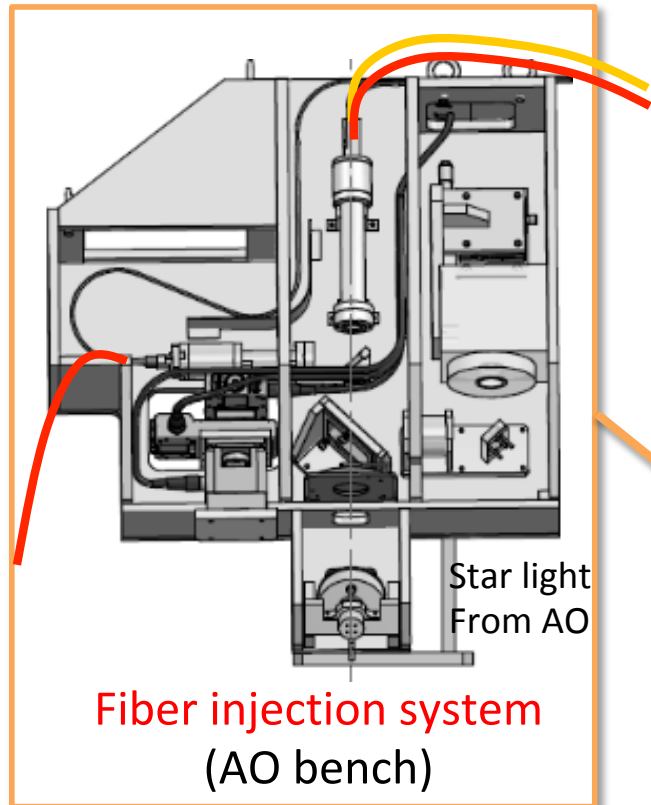Co-PI: Nagayoshi Ohashi (NAOJ, Subaru)

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1. Hokkaido University; 2. NAOJ; 3. JPL/Caltech; 4. UC Santa Barbara; 5. Subaru Telescope; 6. University of Victoria; 7. ELSI; 8. Tokyo Institute of Technology; 9. NASA Goddard; 10. University of Arizona; 11. Astrobiology Center, NINS; 12. Nicolaus Copernicus Astronomical Center; 13. MPIA; 14. Photocoding; 15. University of Tokyo; 16. ISAS/JAXA; 17. Stockholm University; 18. Miyagi University of Education; 19. Space Science Institute; 20. Kyoto University; 21. SOKENDAI; 22. Princeton University; 23. Caltech; 24. Nagoya University; 25. National Meteorological Satellite Center; 26. University of Oklahoma; 27. Osaka University; 28. Kyushu University; 29. University of Washington; 30. TUAT; 31. University of Hawaii, IfA
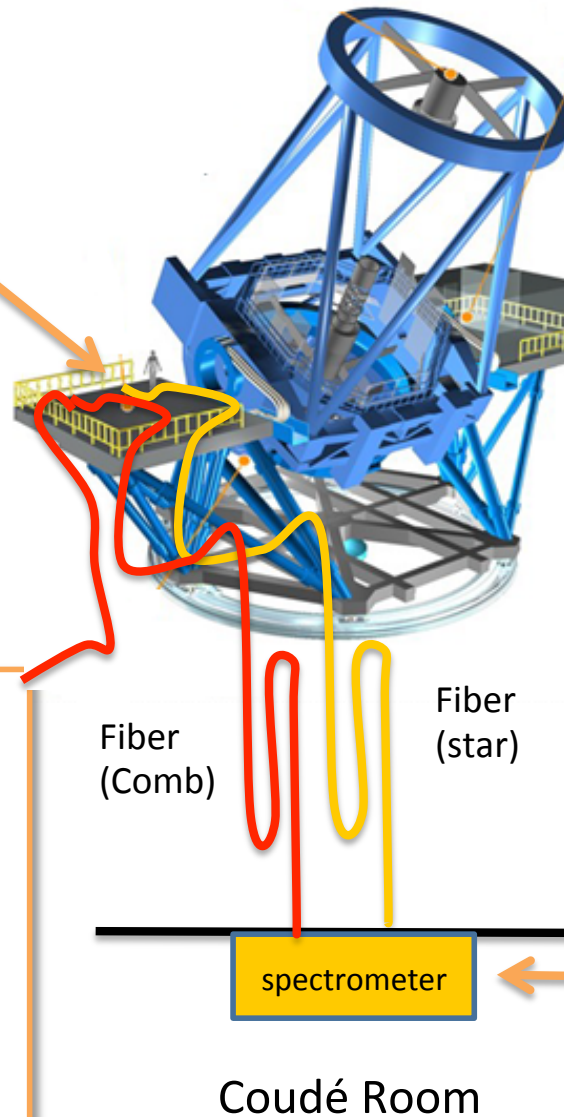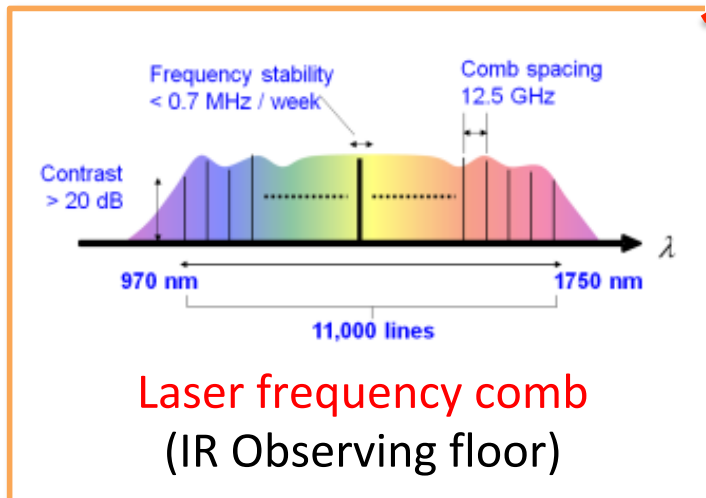
Summary

- InfraRed Doppler instrument (IRD)
  - A high-dispersion (R=70,000) near-infrared spectrograph for Subaru telescope
  - RV precision of ~2 m/s is achievable for M dwarfs

- IRD-SSP
  - We aim at detecting earth-mass (~1-3M_{earth}) planets in habitable zone around late-M dwarfs, and unveiling planet population in wide range of mass and orbit around late-M dwarfs
  - We expect to find ~60 planets in 60 sample stars by 5-year (175 nights; 35 nights/year) survey.
  - The full 5-year survey is now approved.
  - Observations have been conducted almost every month since S19A.
  - The initial screening observation has been almost completed and intensive monitoring for some targets has started.
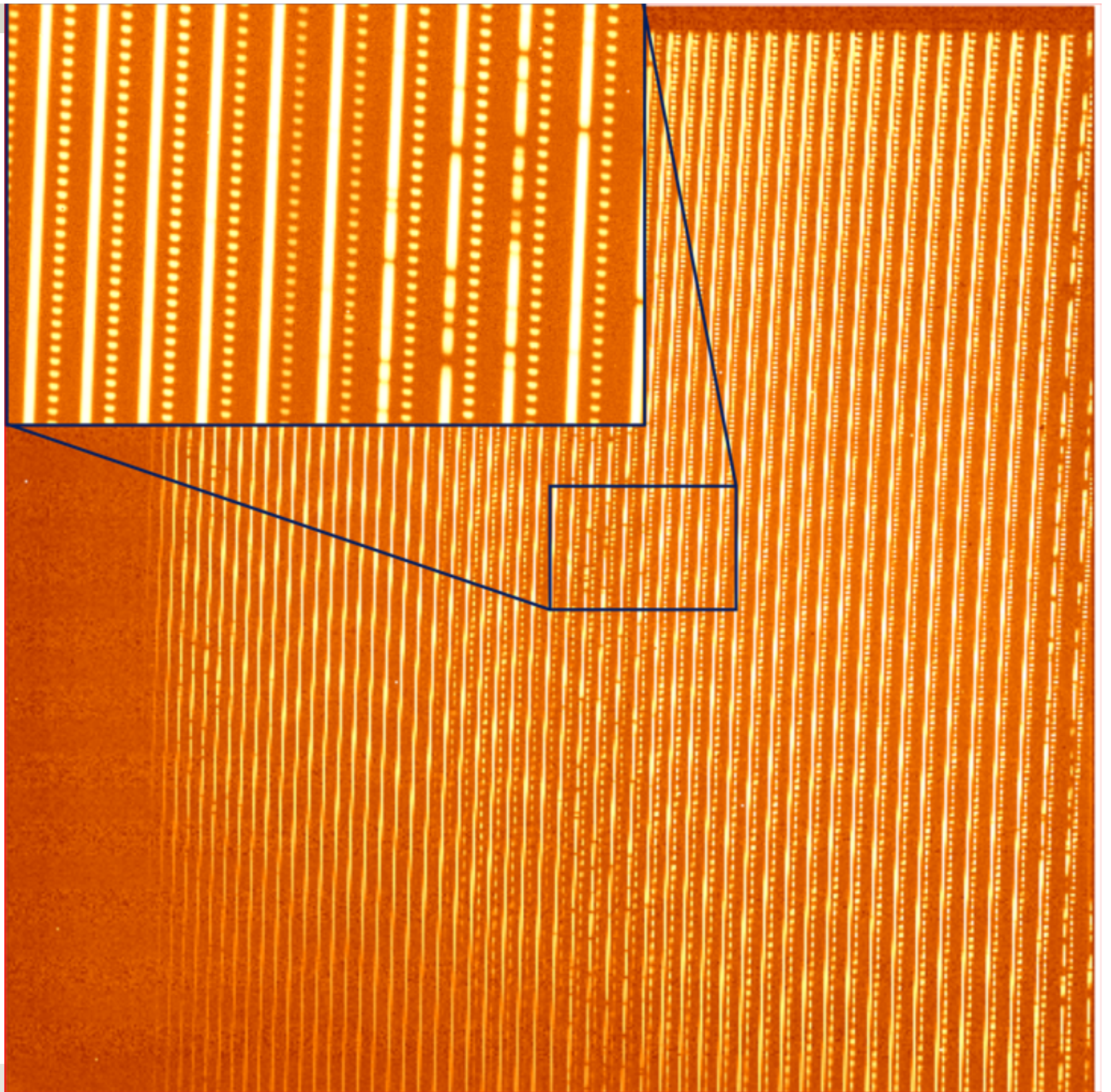
Overview of the IRD instrument

Fiber injection system
(AO bench)

Star light
From AO

Mode scrambler

Resolution: R=70000
Wavelength: 0.97-1.75um
Cryo: 80K (detector), 180K (optics)

Fiber
(Comb)

Fiber
(star)

spectrometer

Coudé Room

Spectrometer system
(Coudé room)

Frequency stability
< 0.7 MHz / week

Comb spacing
12.5 GHz

Contrast
> 20 dB

970 nm   1750 nm

11,000 lines

Laser frequency comb
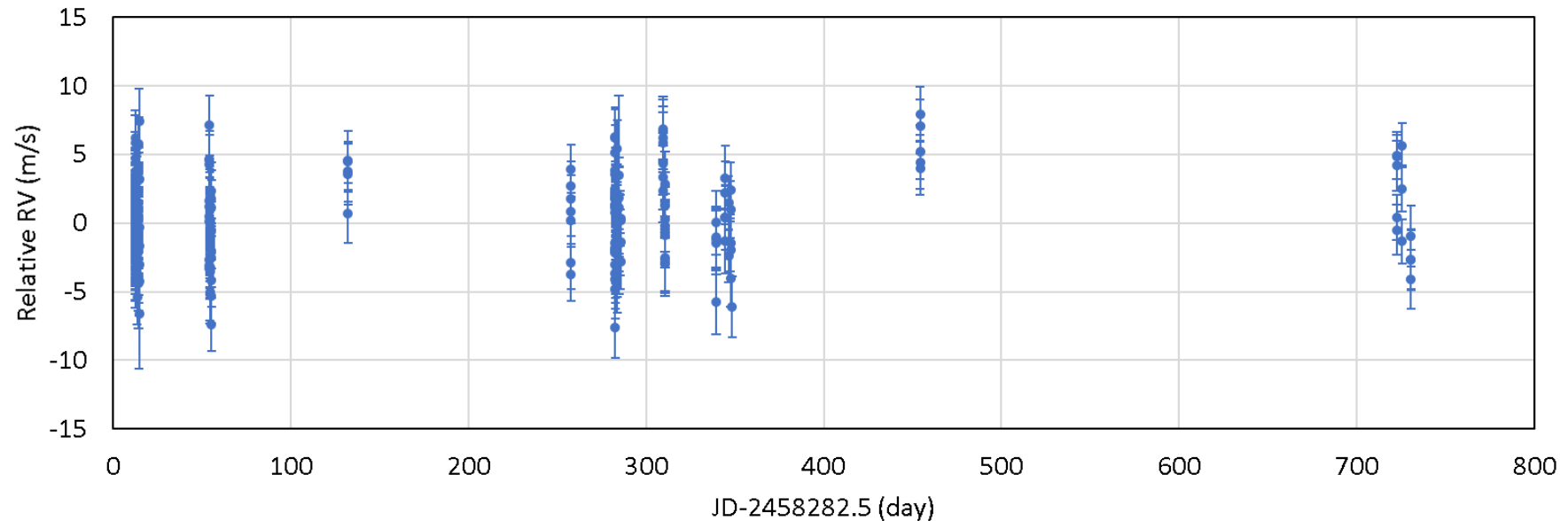(IR Observing floor)

6

GJ 436
(M3V)

July, 2018

Long-term monitoring of an RV standard, Barnard's Star (M4V)

	Number of the data	Total error	Internal error	Instrument + Activity error
Selected data*	280	2.9 m/s	2.1 m/s	2.0 m/s
All data	299	3.2 m/s	2.1 m/s	2.4 m/s

*The data with low comb-intensity are excluded.

Detailes of RV-analysis procedure for IRD are presented in Hirano et al. (2020)

Brief summary of 2019-2020

- Allocated nights
  - S19A: 16.5
  - S19B: 17.5
  - S20A: 17.5
    - suspended : 2.5nights (COVID-19)
  - S20B: 19.5
    - ToO : 0.5nights

- Rough success rate
  - S19A: ~77%
  - S19B: ~60%
  - S20A: ~75%
  - S20B: ~68%

Current progress of observation

	observed stars
stars observed once	26
stars observed twice	11
stars observed 3-9 times	74
stars observed >10 times	14

Sample selection

- D<25pc, M=0.08-0.25$_\odot$, J<11.5, no Ha emission (1st screening)
  - → 149 stars were selected by low-resolution spectroscopy.
    (e.g. Koizumi et al. 2021, PASJ, 73, 154)

- Double-line spectroscopic binaries and rapid rotators will be screened out by initial observations with IRD (2nd screening)
  - → Best 60 stars will be selected for IRD survey.
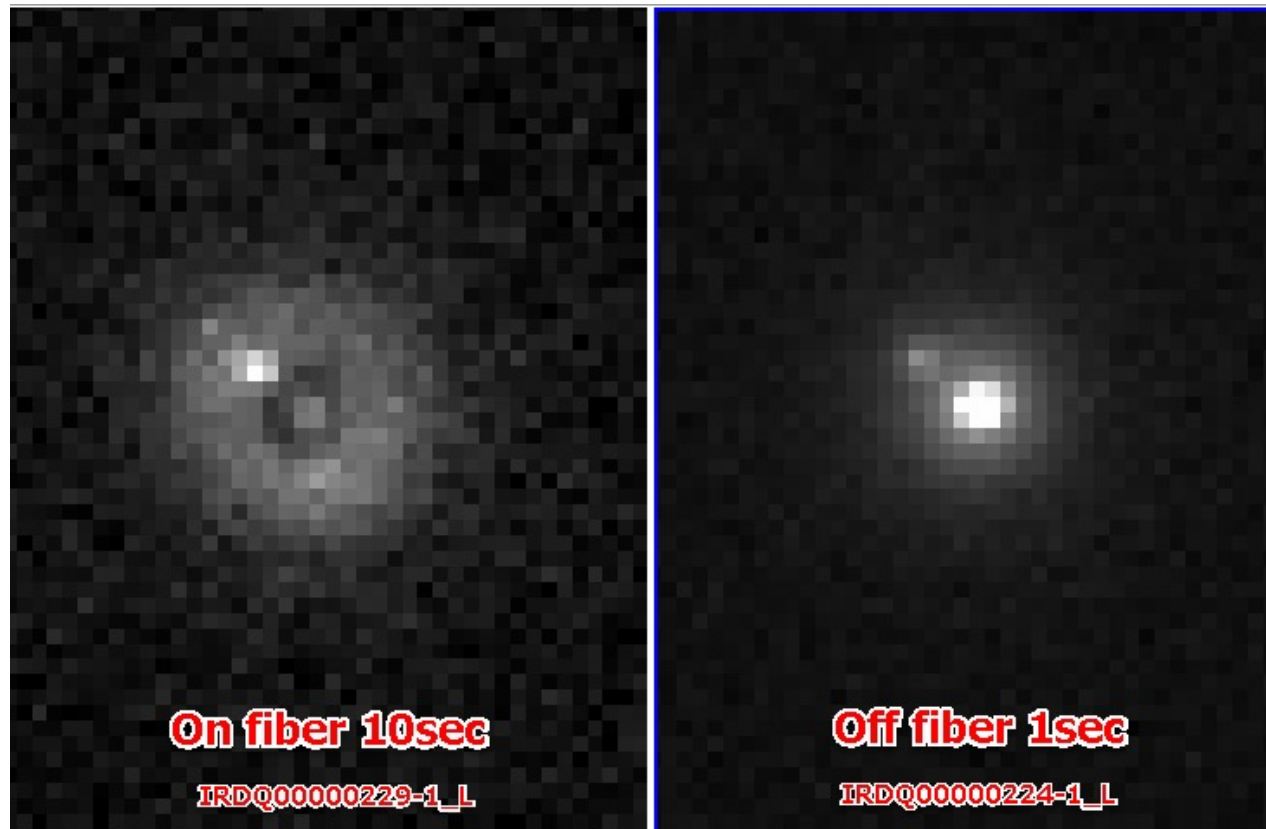   38 stars have been selected so far and intensive monitoring for them has started.
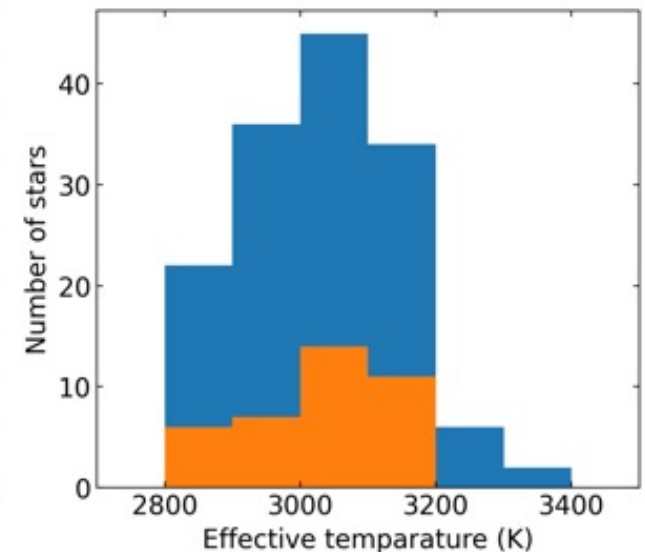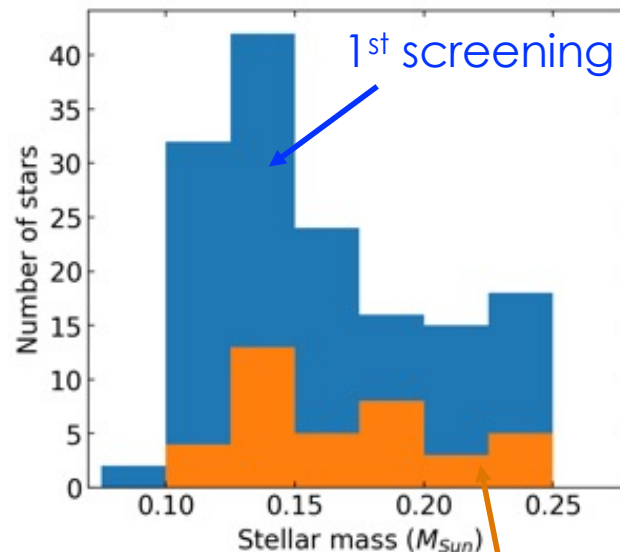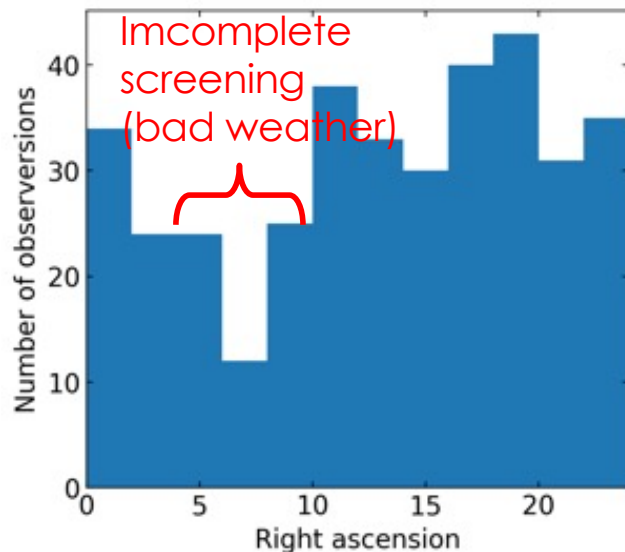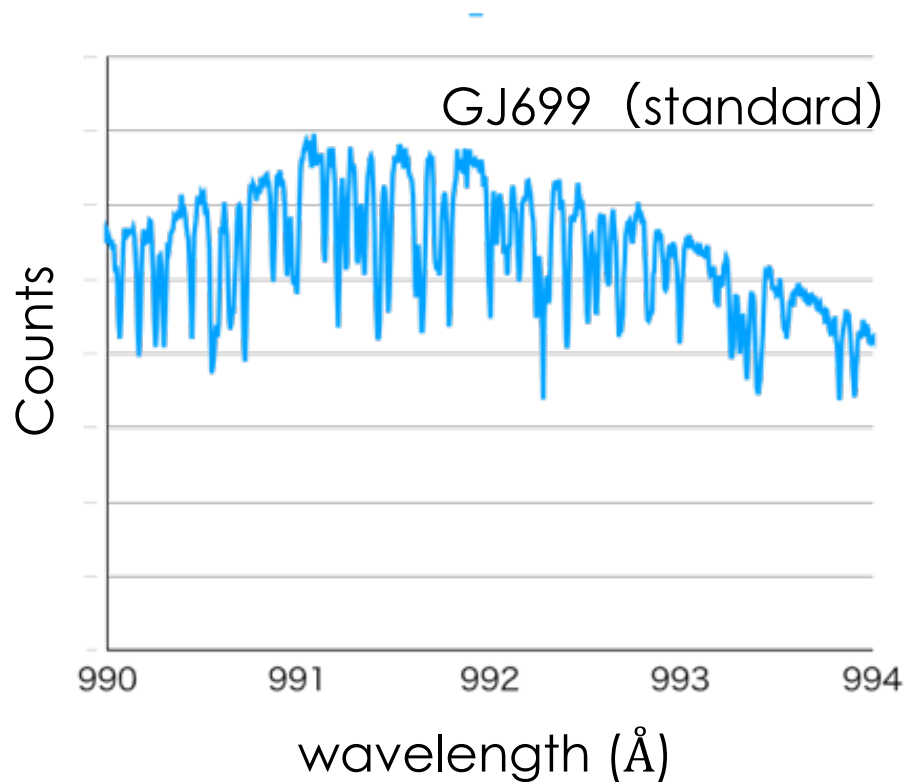

As of July, 2020

Screening: AO images

- To check existence of visual companions in the images of IRD-FIM
- e.g. A companion with contrast ratio 1:7 = M4 : M7
  - Angular separation = 0.2", distance 17.7pc ➜ 3.5AU (P~13.5yr)

Screening: Spectral shape
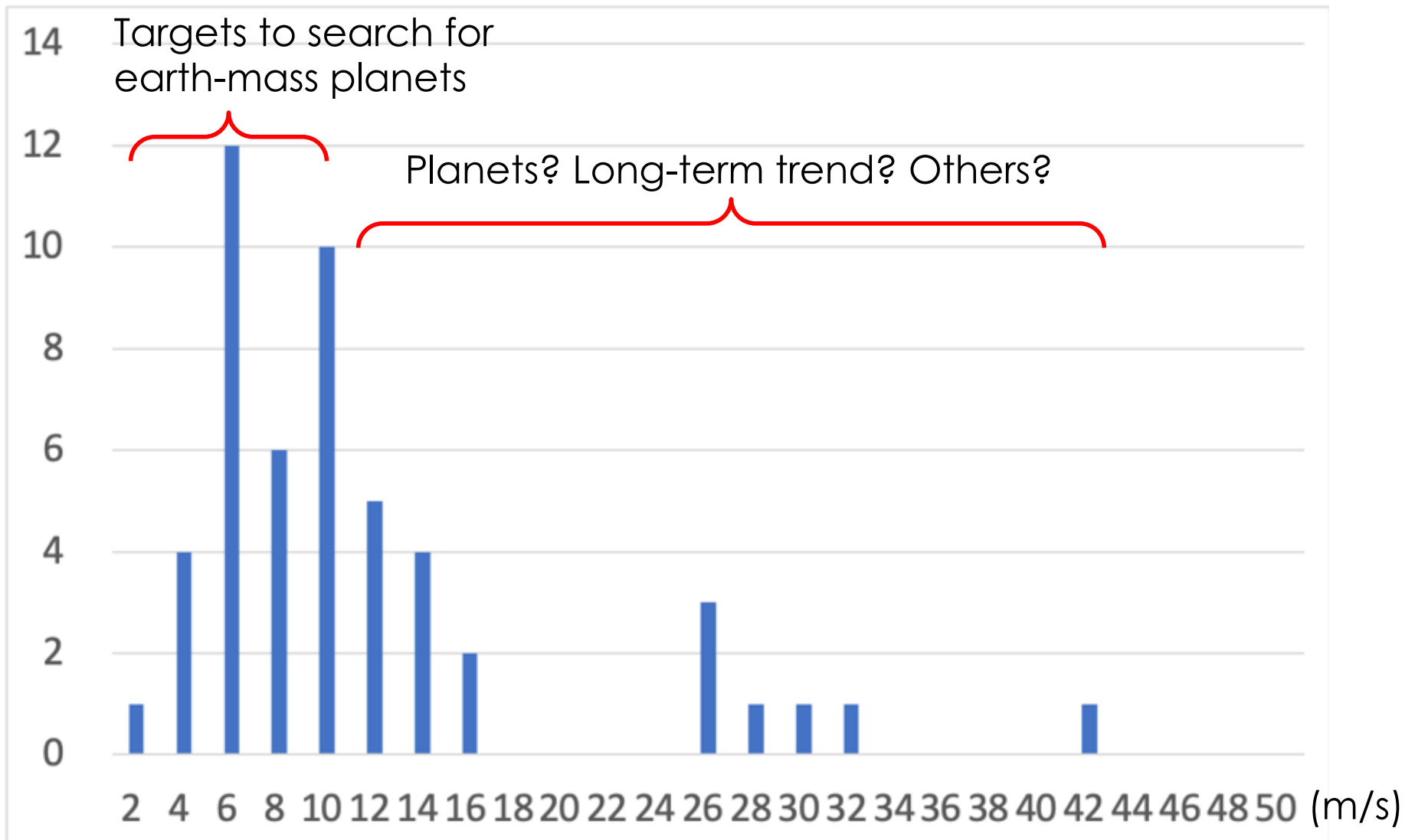

GJ699 (standard)

Counts

wavelength (Å)

Rapidly rotating stars ?

double lines binary ?

From HR spectra we also check
Activity indicators (line shape, Pachen, He I)
Metallicity

RV scatters measured with IRD

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