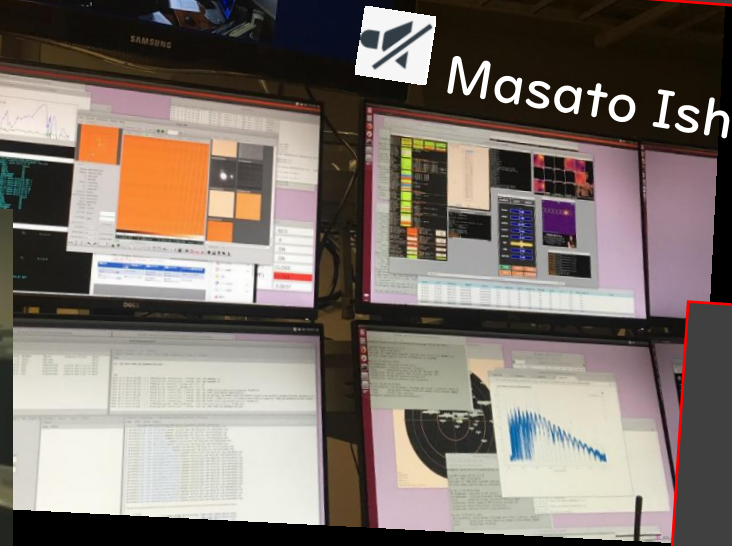
REACH

Scientific Overview of Extremely High-Contrast Spectroscopy at the Subaru Telescope

Hajime Kawahara (U Tokyo)
REACH collaboration

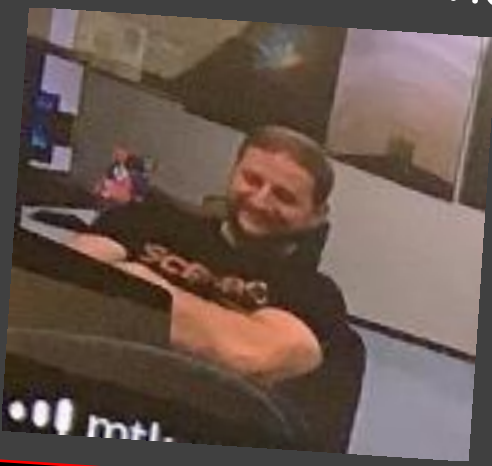


Masato Ishizuka

The first real spectrum by REACH in Oct 16th (2019)

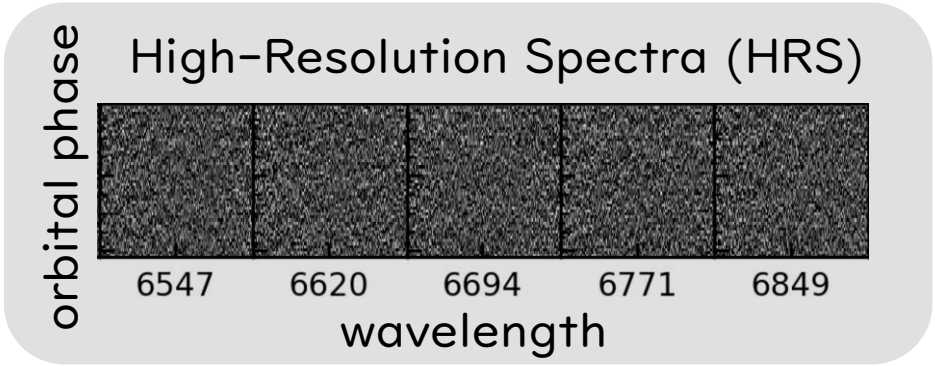
Takayuki Kotani

Ananya Sahoo



Nemanja Jovanovic

HRS detection of molecules in planetary atmosphere



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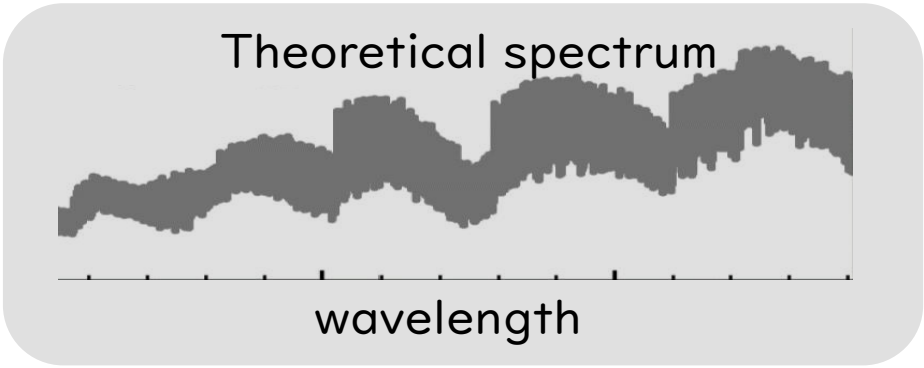

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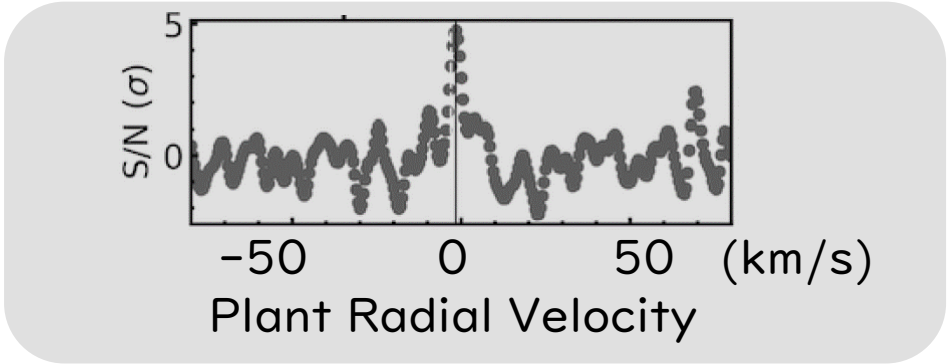
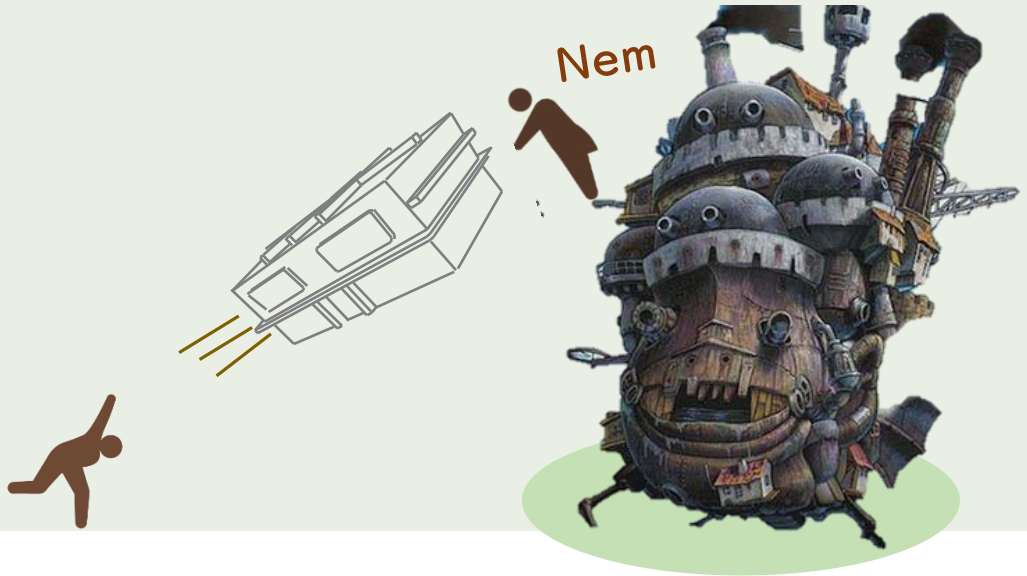


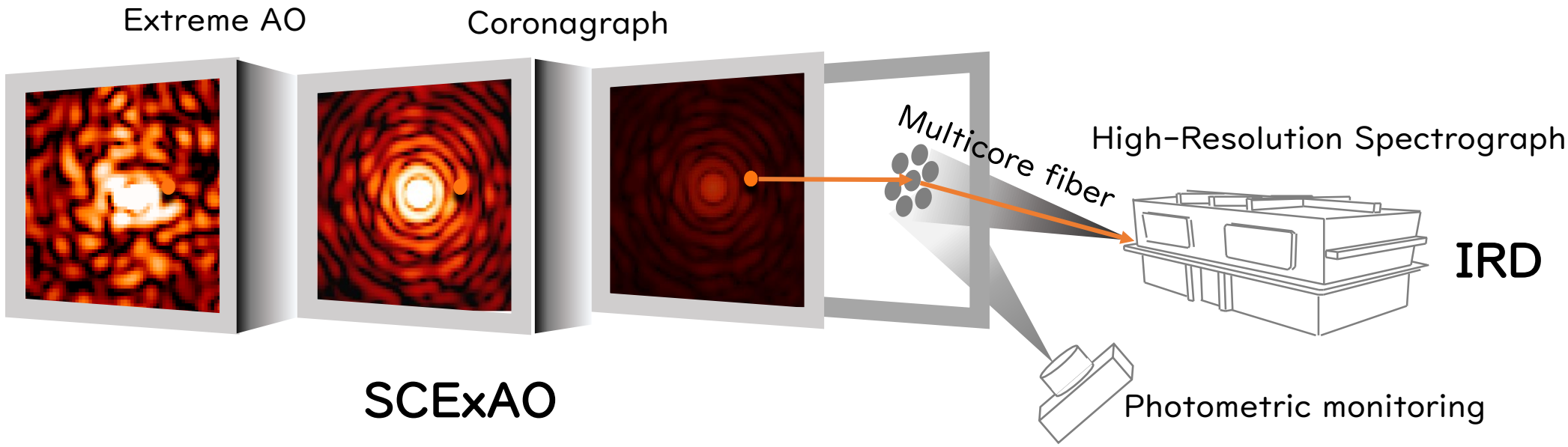
Transmission CO (Snellen+2010), **Metals** (Hoeijmakers+)
Emission CO (Brogi+2012 etc.), H2O (Birkby+2013)
TiO (Nugroho, *H.K.*+2017), HCN (Cabot+2019)
Imaging CO, H2O (Konopacky+2013, Snellen+2014, Hoeijmakers+)

HRS with Coronagraph? No scientific results yet
e.g) Kawahara, Murakami, Matsuo, Kotani, ApJS 212, 27 (2014),
"Spectroscopic Coronagraphy for Planetary Radial Velocimetry of Exoplanets"
Snellen+2015, Jovanovic+2017, Wang+2017, also Sparks & Ford 02

REACH: HCI (SCExAO) + HRS (IRD) since 2014



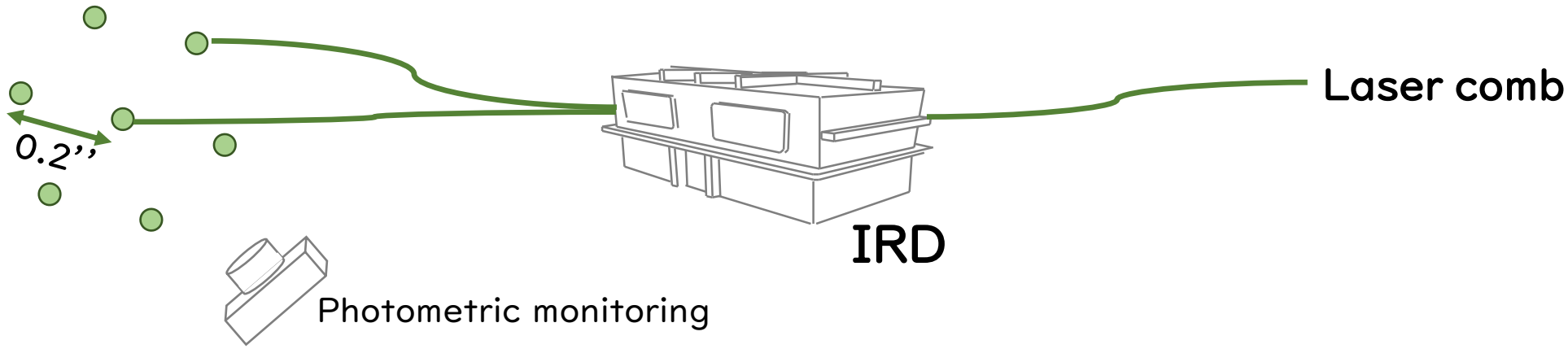
High Dispersion Coronagraph (HDC or HRS-C) by REACH project



Recipe of REACH

A Select your favorite (or no) coronagraph (Lyot, 8oct, vortex so on) in SCExAO

B The REACH multicore fiber has 7 ports. Select two inputs to IRD.



C Available Y, J, and H with R =100,000 thanks to SMF

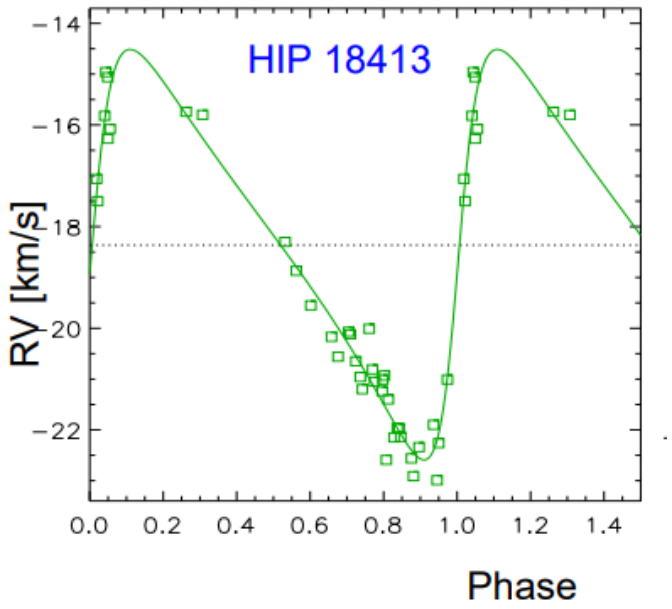
Advanced option 1: You can use 1 in 2 fibers for laser comb.

Advanced option 2: The REACH monitoring camera for speckle nulling.

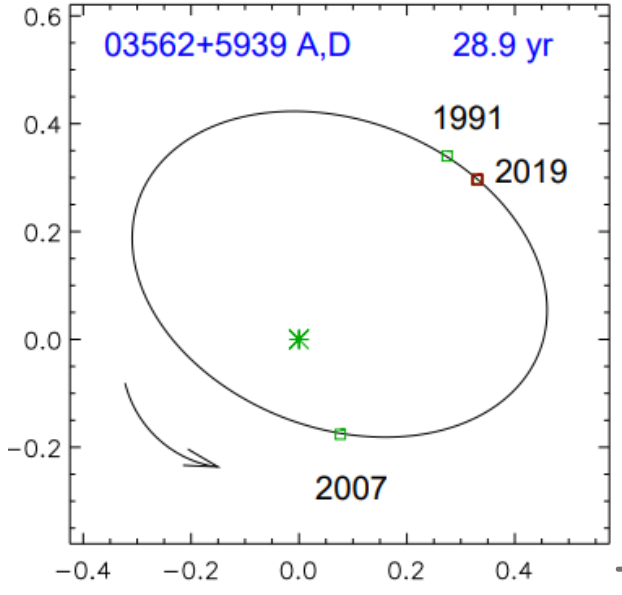
Demonstration

Target: Spectroscopic Binary (SB1) HIP18413

RV of the host star



Speckle interferometer



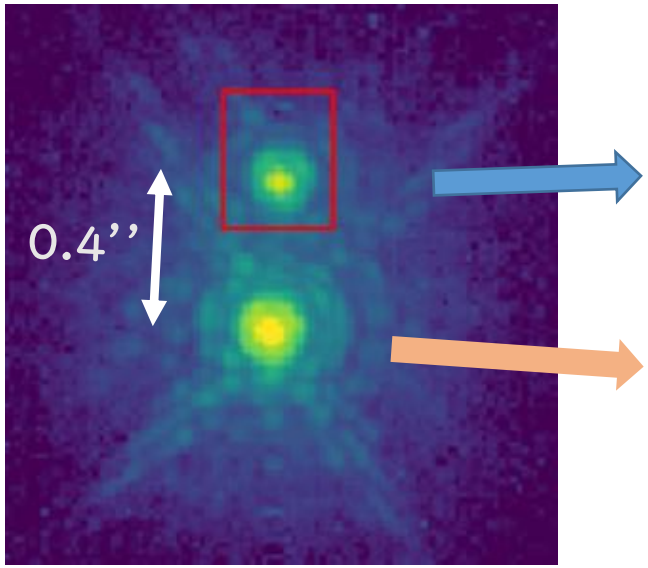
Tokovinin+2019

The lines from a companion was unavailable (SB1).

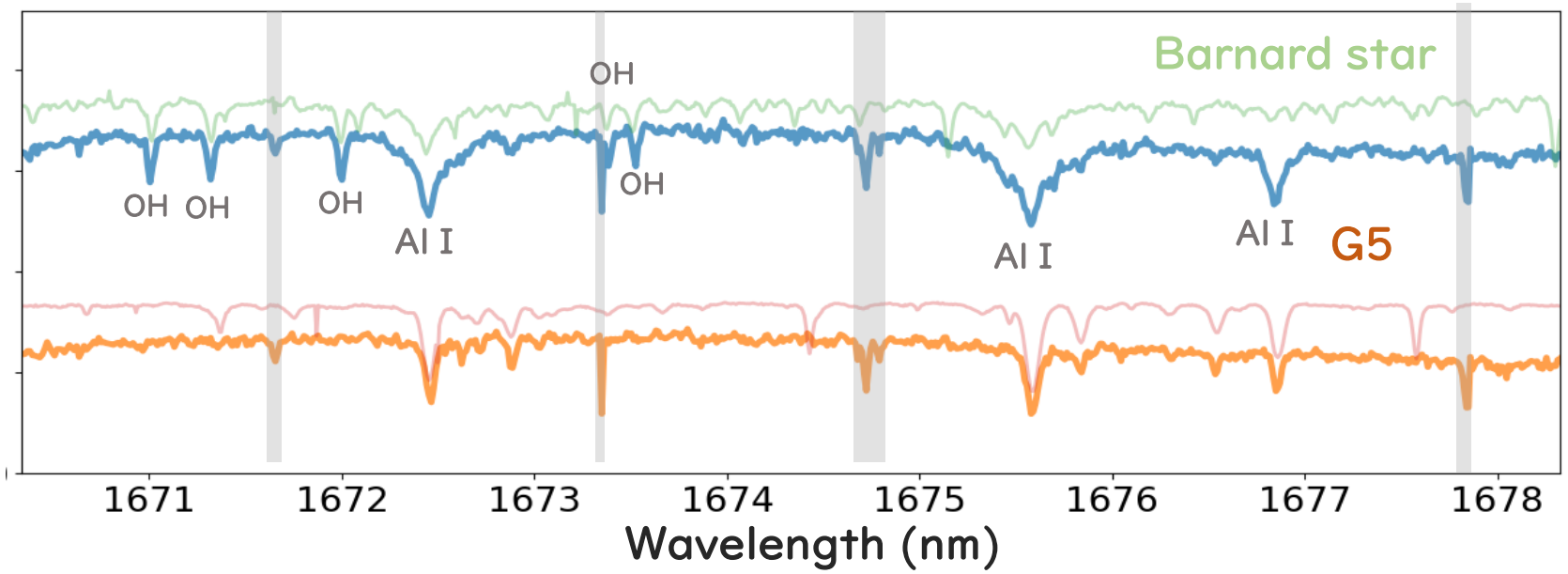
Demonstration

HRS with No Coronagraph by REACH

HIP 18413



1:~10 (J) - 1:4 (H)



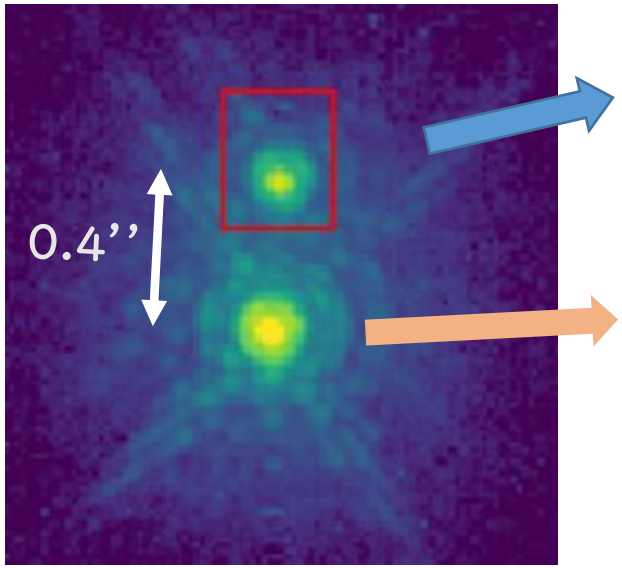
We got a spectrum of a companion D, completely separated from A!
REACH reveals HIP18413B is early-mid M.

From engneering run in Oct 16th (2019)

Demonstration

High S/N spectrum in 10 min exposure for a M-type companion at 23 pc

HIP 18413



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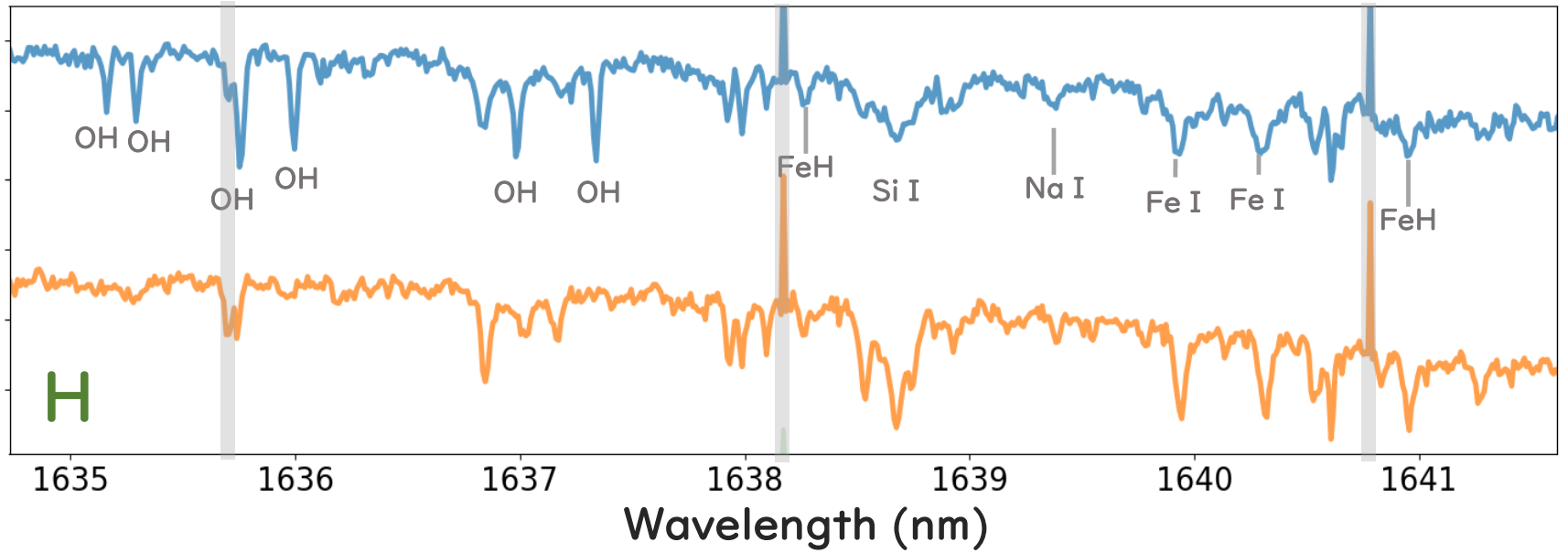

Relative RV ~ 0km/s > more precise CCF analysis is needed > dynamical masses of the stars

From engneering run in Oct 16th (2019)

Demonstration

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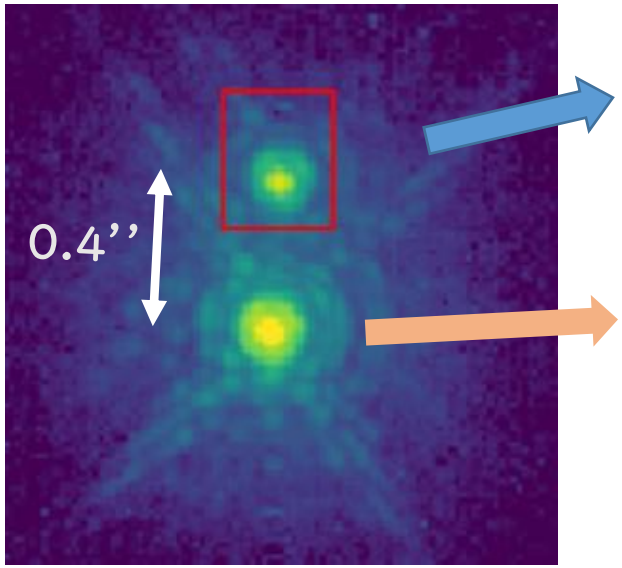

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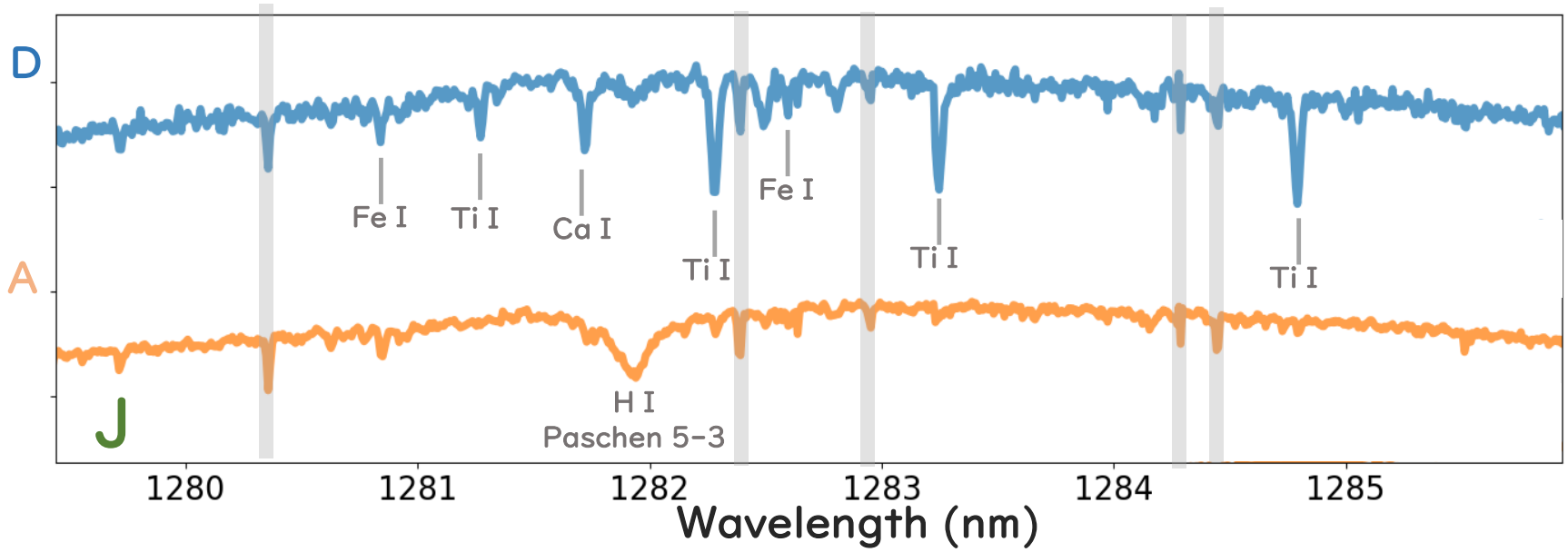

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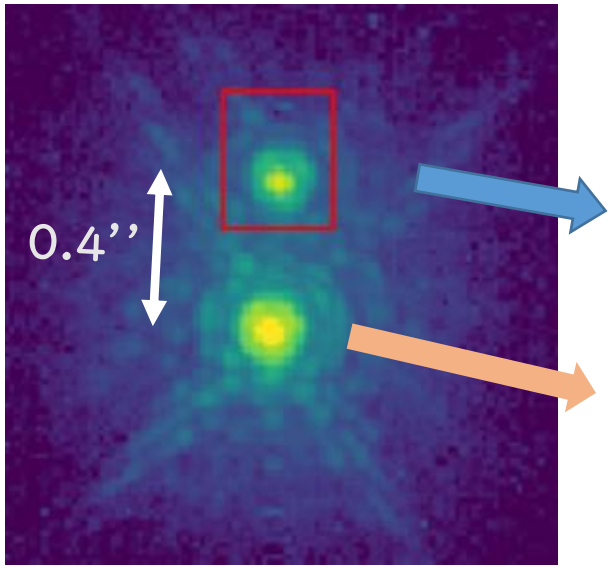

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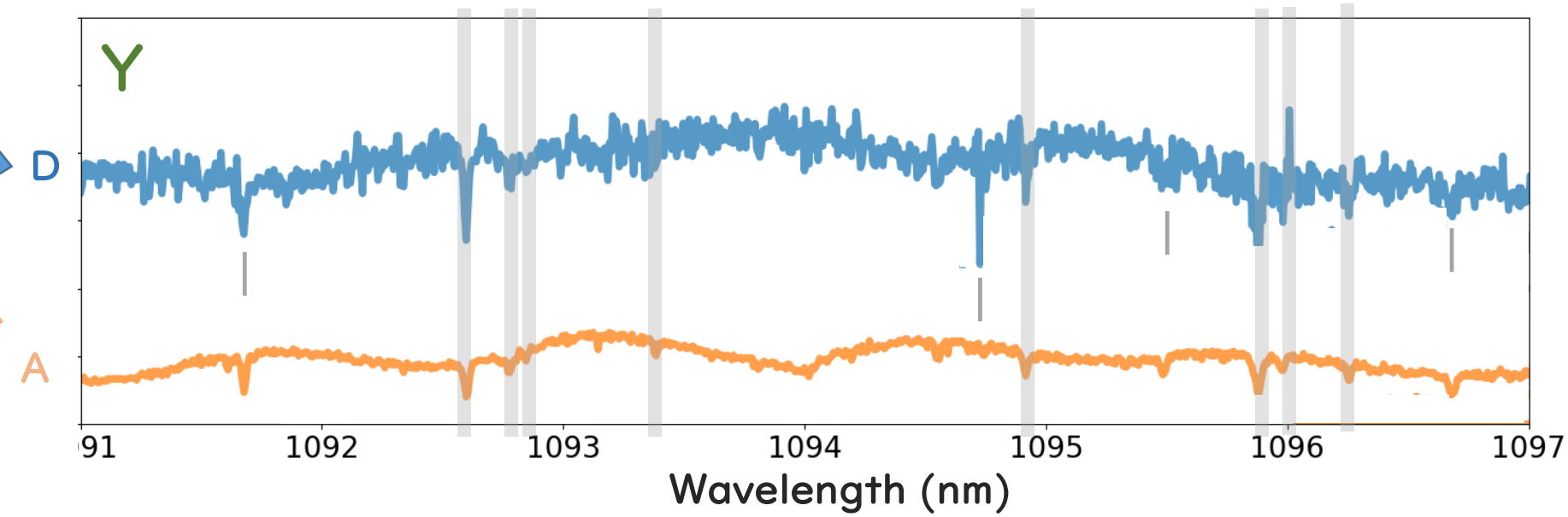
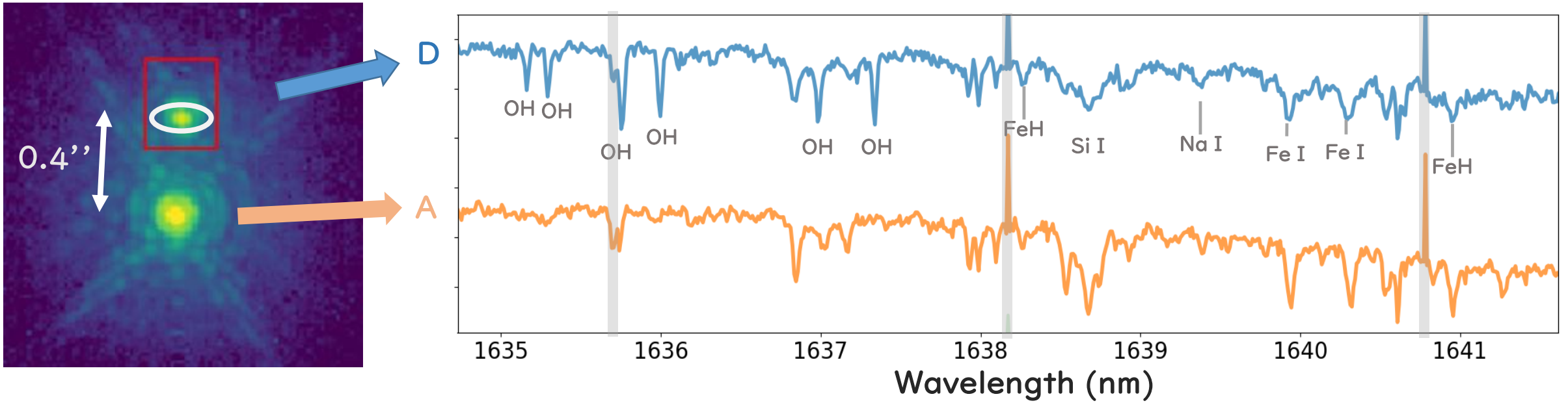


Relative RV ~ 0km/s > more precise CCF analysis is needed > dynamical masses of the stars

From engneering run in Oct 16th (2019)

Science case # 1 : Precise Radial Velocimetry of a Companion Star

REACH can reach hidden nearby M-type targets for precise radial velocity survey with laser frequency comb

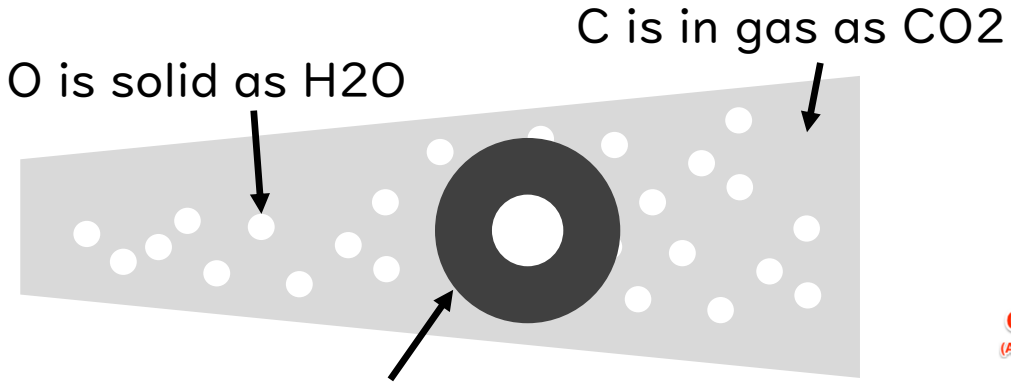


Planet around a binary companion
- Dynamical mass of a companion
- Dynamical planet mass

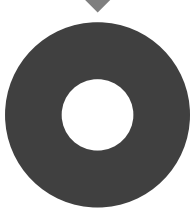
Planet in the HZ around a companion
- Complex climate?
- New survey space

Science case #2: HRS-C for cool directly imaged planets

- In situ formation of gas giants



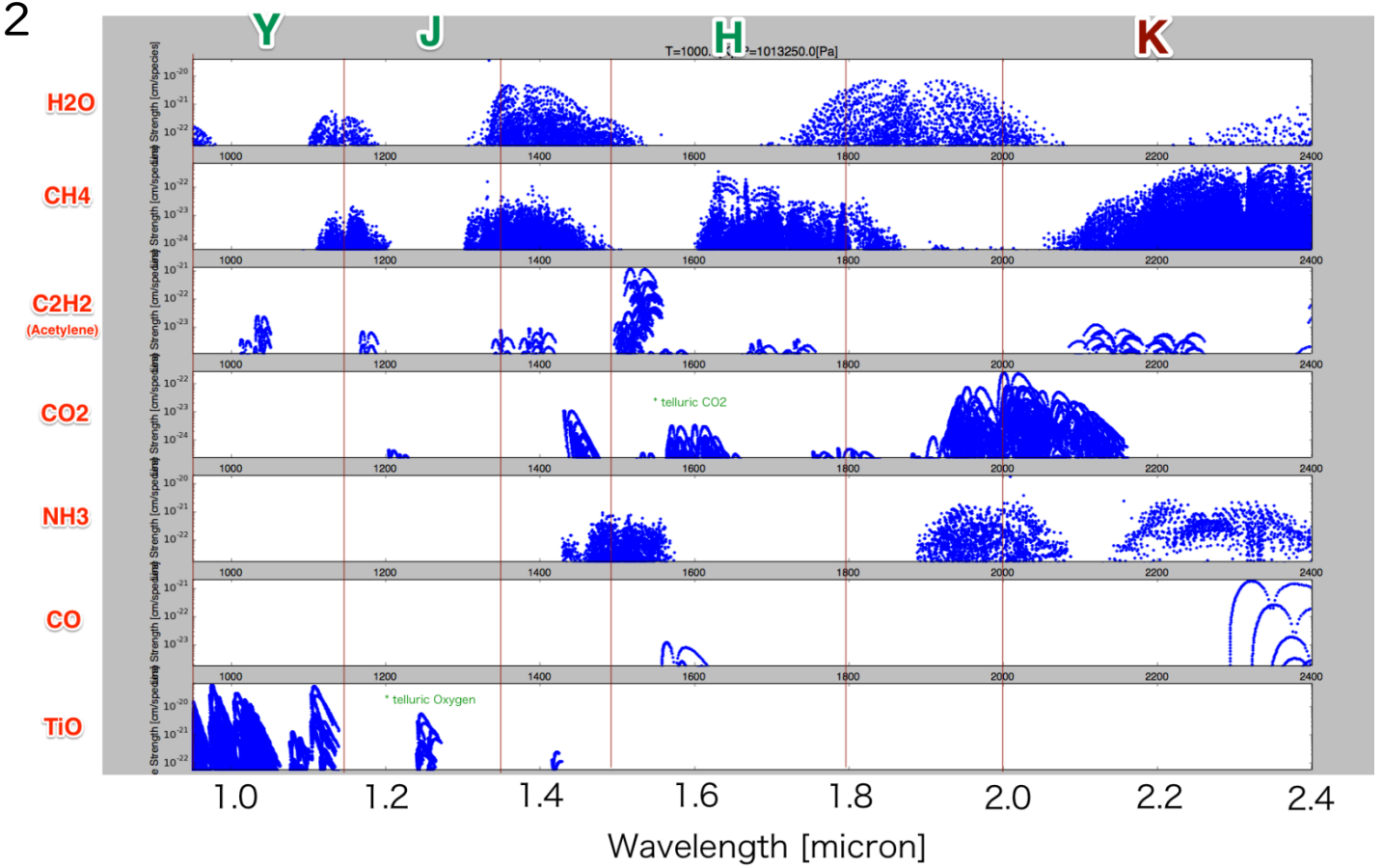
evolution



CH4 rich atmosphere
Current Jupiter?

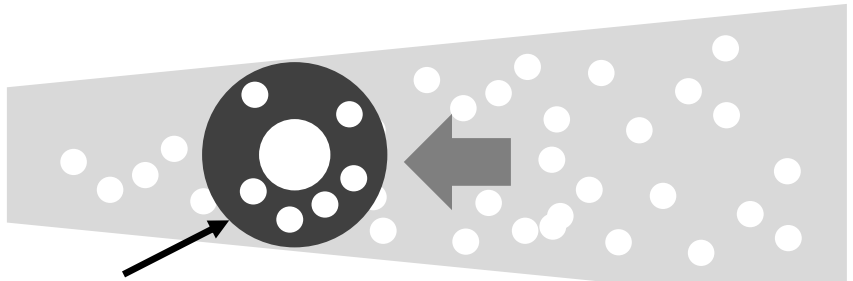
HCN is also available in H band

Use KPIC!

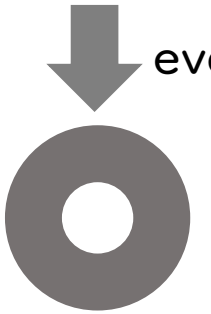


Science case #2: HRS-C for cool directly imaged planets

- Migration injects oxygen in atmosphere



Eating ices!

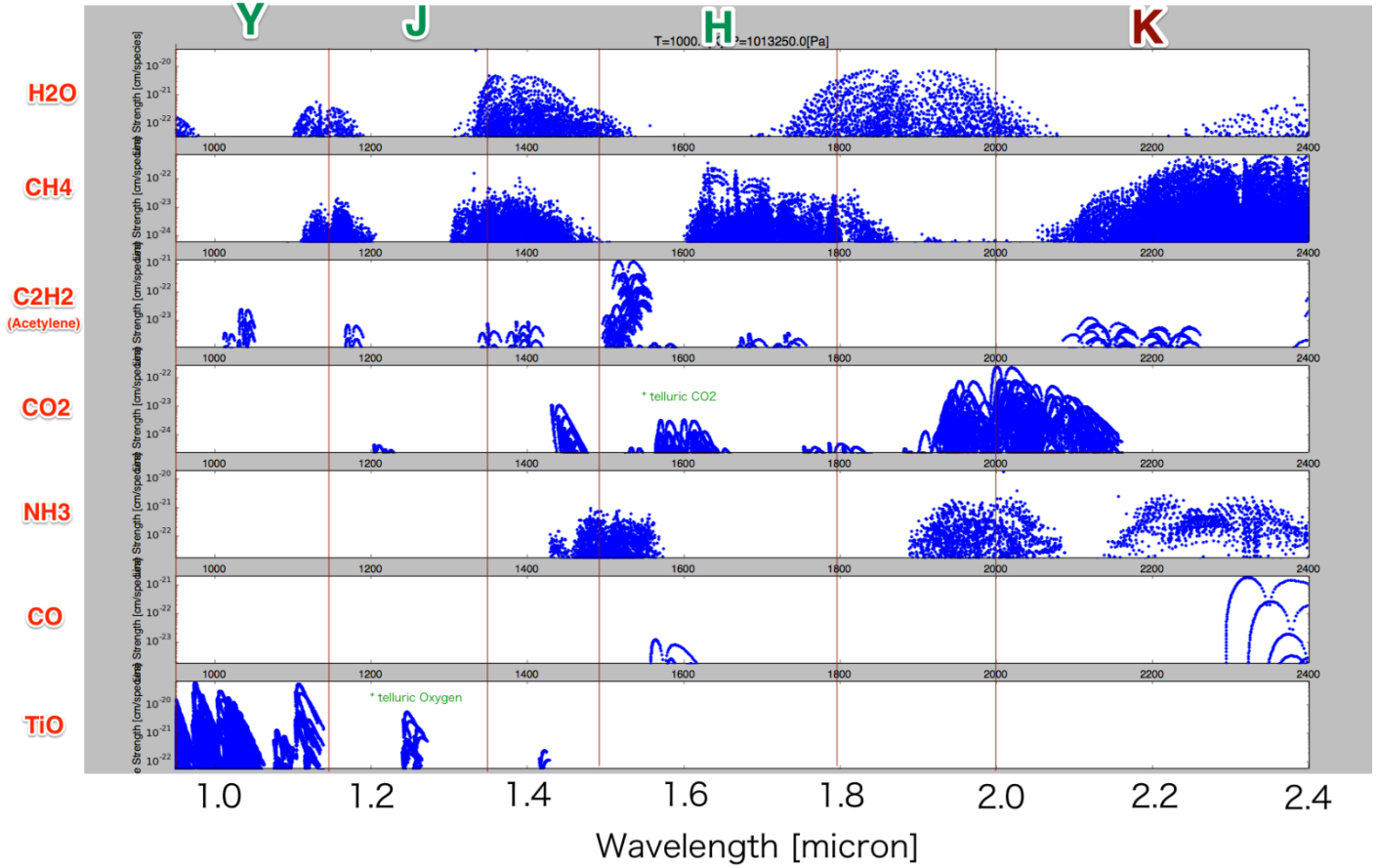


evolution

H2O rich atmosphere

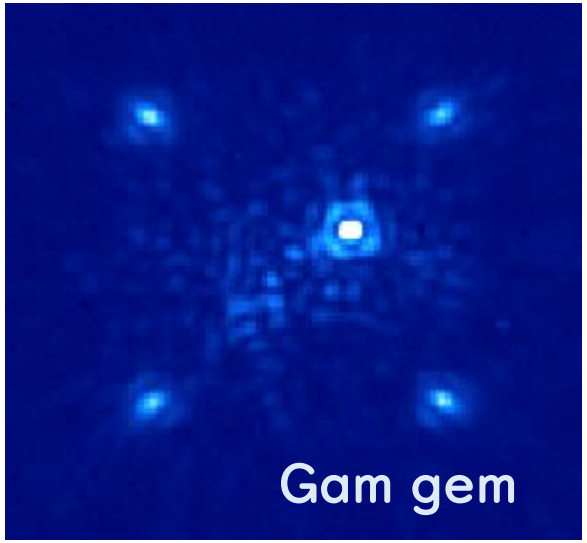
HCN is also available in H band

Use KPIC!

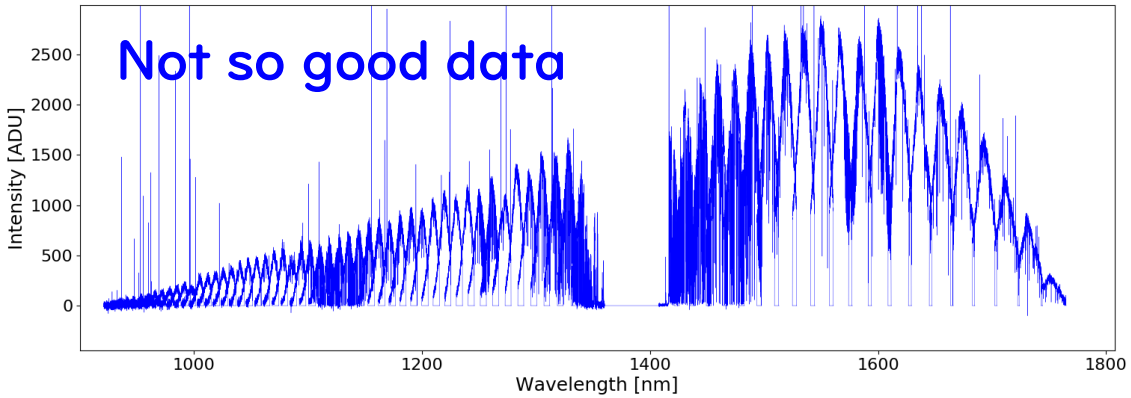


Science case #2: HRS-C for cool directly imaged planets

Ready for targets with low-contrast whose image is visible at raw level (HRS-NC).
But, planet characterization (HRS-C) is much more challenging.



A coronagraph suppresses >50% of speckle from a host star?



From engneering run in Oct 16th (2019)

We need more tests for the HRS-C mode.

1. We need to inject the light based on positions computed from the orbit,
2. Which coronagraph is the best for the HRS-C observation?
3. Telluric removal technique (use another fiber close to a host star?)
4. Accuracy of line list. Always problematic for the HRS analysis. Help us!

Summary

REACH = HCI+HRS on Subaru (y,J,H, R=100,000, northern hemisphere)
or one of the junks on Howl's moving castle

Science cases:
planet molecules, precise RV of a companion, disk science, and your science

Complementary to KPIC (K,L,M) and HiRISE (southern hemisphere)
Open use for S20B? (planned)